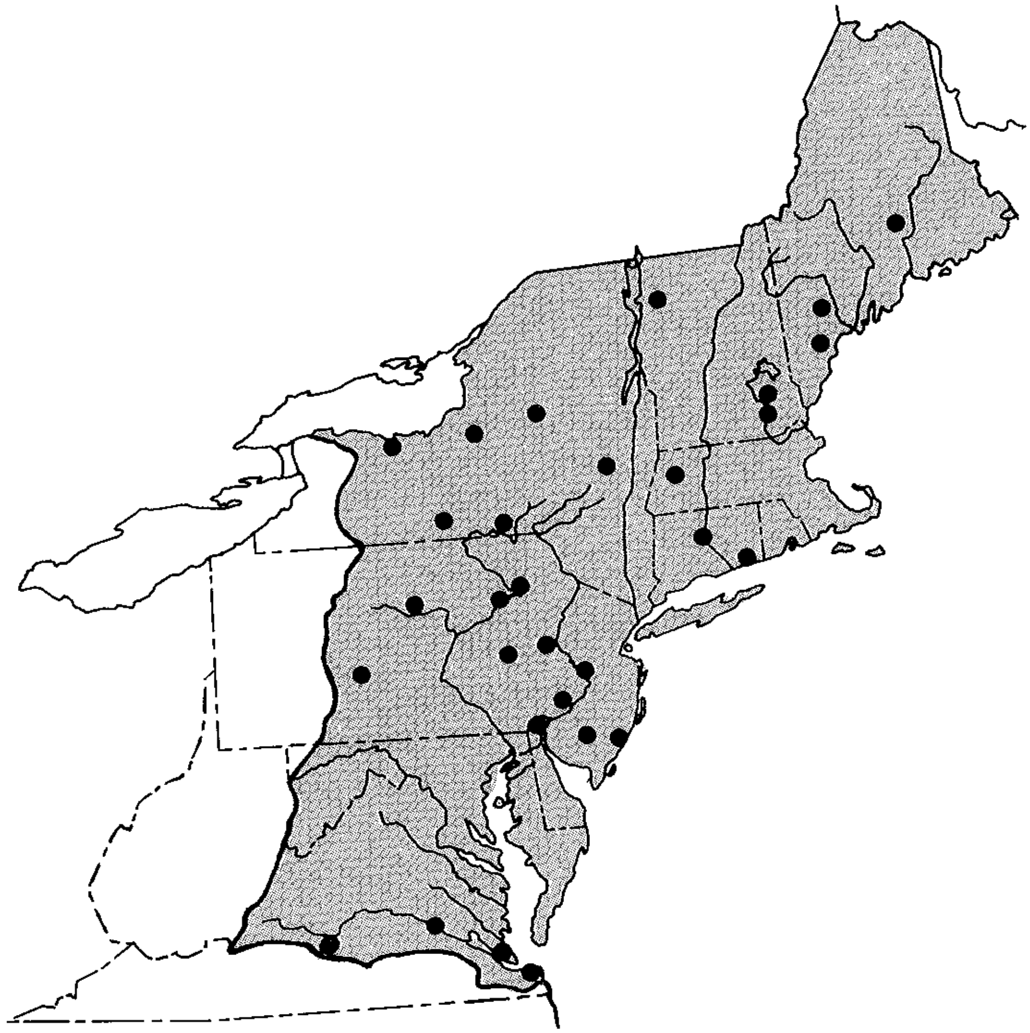
NORTHEASTERN UNITED STATES WATER SUPPLY STUDY

PRELIMINARY STUDY OF LONG-RANGE WATER SUPPLY PROBLEMS OF SELECTED URBAN METROPOLITAN AREAS

VOLUME I MAIN REPORT



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of

SELECTED URBAN METROPOLITAN AREAS

VOLUME I

MAIN REPORT

Prepared for

North Atlantic Division
U.S. Army Corps of Engineers

by

Anderson-Nichols & Company, Inc.
Boston-Concord-Vernon-Horsham

Contract No. DACW 52-71-C-0001
November 1971

The Preliminary Study of Long-Range Water Supply Problems of Selected Urban Metropolitan Areas was conducted by Anderson-Nichols and Company, Inc., Boston, Massachusetts, under contract to the North Atlantic Division, U.S. Army Corps of Engineers as part of the Northeastern United States Water Supply Study. The Study Report is presented in two parts - Volume I, Main Report, and Volume II, Area Reports.

The Main Report summarizes and outlines the methodologies used, and presents the general findings for 26 urban metropolitan areas. The Area Reports includes a chapter for each urban metropolitan area containing detailed population, water supply data, projections to the year 2020, supply deficits, and regional opportunities for solutions to problems.

The Anderson-Nichols effort was conducted under the general direction of Jerome Degen, Senior Vice President, and Warren A. Guinan was Project Coordinator. Project Engineers included Richard C. Boynton, Anthony S. Donigian, Jr., Joseph G. Hugo, Stephen D. Parker, and Frederick H. Sharrocks, Jr.; and Charles W. Amos, Edward A. Rainen, Ron Etzion, and Stanley J. Portman were Engineering Assistants.

PREFACE

In the densely populated northeastern United States, where four of every five people live in urbanized areas, water is carried to its users by numerous complex systems, involving dams, reservoirs, aqueducts, pumping plants, water treatment plants, and intricate pipeline networks. Despite these seemingly adequate systems, the five-year drought of the 1960's created an emergency situation: extra pipelines were pressed into service, some areas were actually supplied with drinking water by tank trucks; and about 14 million people, or 28 percent of the Northeast's population, were subjected to restrictions on water use.

While that drought is now history, it demonstrated clearly that many water supply systems in the Northeast were barely adequate to meet demands, even under severe restrictions and emergency operations.

Since the drought, some communities have made substantial progress in expanding their water supply capabilities. However, many others have not been able to expand because of policitical, economic, or environmental reasons. A recurrence of a drought similar to that of the 1960's in these areas would have much more severe implications, because increases in population and technological advances bring about greater demands for water. It is projected that the population of the Northeast will increase by 70 percent, from 50 million to 85 million people, by the year 2020, with corresponding increases in industrial and commercial activity. Water presently required per person, excluding that used to manufacture goods and provide necessary services, is approximately 128 gallons per day. Projections for 2020 increase the total to 153 gallons.

It is clear that the people of the vital northeastern United States need more water - not primarily to provide for the present - but to keep abreast of ever-growing future demands. Planning must transcend the historical concept that water supply is a local problem confronting only local resources and talents.

Presently available water supply facilities will not support projected demands. Water supply planners must consider integrating their plans for development, they must also combine and relate water supply development to other urban needs, such as transportation, communications and power. Though these categories by no means cover everything necessary for urban living, it is easy to see that a shortage of any of them would severely curtail or stop normal development. Competition for water exists among the varied interests created by modern society. Changes in the industrial economy have provided individuals with increased income and leisure time, but such an economy concomitantly expects a need for more water.

Planners at every level are recognizing the need to provide efficient utilization of water resources. In 1965, the 89th Congress recognized the growing importance of coordinated regional planning to meet the future water supply needs of the Northeast, and authorized the formation of the Northeastern United States Water Supply (NEWS) Study, under Title I of Public Law 89-298. The NEWS Study is being conducted by the North Atlantic Division of the U.S. Army Corps of Engineers in cooperation with other concerned Federal, State, regional and local government agencies and with the water supply industry. The study will analyze current and long-range needs, with emphasis on urgent problems, and produce coordinated general plans for water supply development and management.

The objectives of the NEWS Study are

1. To establish guidelines for Federal participation in water supply development.

2 To develop coordinated, regional plans for the efficient construction, operation and maintenance of water supply developments in the Northeast.

3. To recommend "action" programs for Federal, State, regional and local agencies, and for public organizations.

4. To select programs and geographic areas which may require continued planning at the Federal level.

The Preliminary Study of Long-Range Water Supply Problems of Selected Urban Metropolitan Areas is a major element of the NEWS Study. It analyzes the long-range municipal, industrial and domestic water supply requirements of 26 selected urban metropolitan areas throughout the Northeast. The 26 areas may experience major regional problems in assuring water supplies during the study period, the present through the year 2020.

Two general planning assumptions evolved to guide the development of this report and to assure that its findings are valid. They are:

- that water provided for domestic and industrial supply will have a very high (if not the highest) priority among all uses of water throughout the planning period; and

- that use of water for this purpose need have no permanently adverse effect on the environment.

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CHAPTER 1. INTRODUCTION

The drought of the 1960's, which caused unprecedented water supply emergencies and restrictions in many locations throughout the Northeastern States, led to the initiation of the Northeastern United States Water Supply (NEWS) Study. The Preliminary Study of Long-Range Water Supply Problems of Selected Urban Metropolitan Areas is a major element of the NEWS Study.

THE NEWS STUDY

The NEWS Study was authorized under Title I of the 1965 Flood Control Act (PL 89-298), in which the Congress recognized that assuring adequate supplies of water for metropolitan centers has become a problem of such magnitude that the welfare and prosperity of the Nation require Federal Government assistance in the solution of water supply problems. The Act directed the Secretary of the Army, acting through the Chief of Engineers, to cooperate with Federal, State and local agencies in preparing plans in accordance with the 1965 Water Resources Planning Act (PL 89-80) to meet the long-range water needs of the northeastern United States.

The NEWS Study area includes all of the river basins within the United States that drain into Chesapeake Bay, into the Atlantic Ocean north of Chesapeake Bay, into Lake Ontario, and into the St. Lawrence River. The study area, stretching some 1,000 miles from the northern-most tip of Maine to the southern boundary of the James River basin in Virginia, encompasses Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, the District of Columbia, and parts of New York, Pennsylvania, Maryland, Virginia, and West Virginia. The area extends inland an average of 200 miles from the Atlantic Ocean and covers approximately 200,000 square miles.

The population of the Northeast is now about 50 million, 25 percent of the national population, and is projected to reach about 85 million by the year 2020. The present population is largely urban, with some 60 percent concentrated in the five metropolitan areas of Boston, New York, Philadelphia, Baltimore, and Washington. Twenty of the Nation's 100 largest cities are located in this area, and municipal water suppliers serve populations as large as 8.5 million, the approximate number of consumers in the New York City system.

The NEWS Study report will assess present and future water supply problems on a regionalized basis, and present multiple-objective, alternative plans for their solution, over a planning period extending through 2020, with intermediate benchmark planning years of 1980 and 2000.

The study effort is being fully coordinated with concurrent regional, river basin, and other water resources studies being conducted in the Northeast. This will assure that NEWS Study plans are consistent with, and integral to, all broad water resource development programs being formulated, and that planned water supply facilities will achieve maximum benefit.

Initiated in 1966, the NEWS Study has progressed to a point where preliminary studies have been completed in the following four major areas where further water supply development is considered urgent:

- the Northern New Jersey-New York City-Western Connecticut Area
- the Metropolitan Washington, D. C. area
- Southeastern New England
- South-Central Pennsylvania

Major study efforts are now underway in the Southeastern New England, Northern New Jersey-New York City-Western Connecticut, and Metropolitan Washington Areas. These survey scope studies will develop alternative project oriented plans for solving water supply problems in these urgent areas

THE UMA STUDY

The Preliminary Study of Long-Range Water Supply Problems of Selected Urban Metropolitan Areas (UMA Study) is an evaluation of the water supply situations of 26 urban metropolitan areas throughout the NEWS Study Area, whose water supply problems are considered to be less serious than the four urgent areas.

The 26 urban metropolitan areas covered in this study were selected on the basis of population and derived from 28 Standard Metropolitan Statistical Areas (SMSA's) defined by the U.S. Office of Budget and Management and four urban areas which are projected to qualify as SMSA's by the year 2020.

The three general objectives of the UMA Study are:

- To determine and identify those metropolitan areas within the NEWS Study area which may evidence major regional problems in meeting municipal, domestic and industrial water supply requirements through the year 2020, excluding the four urgent areas;
- To estimate the magnitude, nature and time phasing of the expected problems; and
- To develop guidelines and opportunities for regional supplies, or other alternative solutions.

The study effort was directed toward the delineation and description of the UMA's, projections of population and water requirements through 2020; and the assessment of the current water supply capabilities and planning in each UMA. The differences between water requirement projection and current supply capabilities determined each UMA's water deficit.

This report presents regionalization opportunities and other alternatives for the solution of the water supply problems. It recognizes possible difficulties in implementing some of the alternatives because of existing political and institutional restraints. However, all proposals for water supply development were formulated without regard for these restraints.

No attempt has been made to advocate regionalization as the only solution to water supply problems in a UMA. A regional approach, however, seems preferable to piecemeal developments that result in a proliferation of utilities, often wasting resources without actually solving the problem.

This study has relied on available data already developed in previous reports and investigations performed by local, regional, state or federal agencies, with new data being generated only where data were unavailable. Its scope is insufficient to define projects, and it serves only as a tool to assist in the decision process relative to urgency and magnitude of water supply development. The Corps of Engineers does not advocate at this time, in whole or in part, any alternative solution set forth in this study, because it is subject to review and appropriate revision. Neither does the study presume that the alternatives listed for each UMA are complete; at best they are representative.

In the total Northeastern United States Water Supply Study Program, the UMA Study is categorized as a preliminary level study. The two other levels are engineering feasibility and survey scope or authorization study. Based on a thorough evaluation of all the data and analyses included in the two volumes of this preliminary report, the NEWS Study planners will determine the need for feasibility-level study of any of the urban metropolitan areas.

CHAPTER 2. THE URBAN METROPOLITAN AREAS

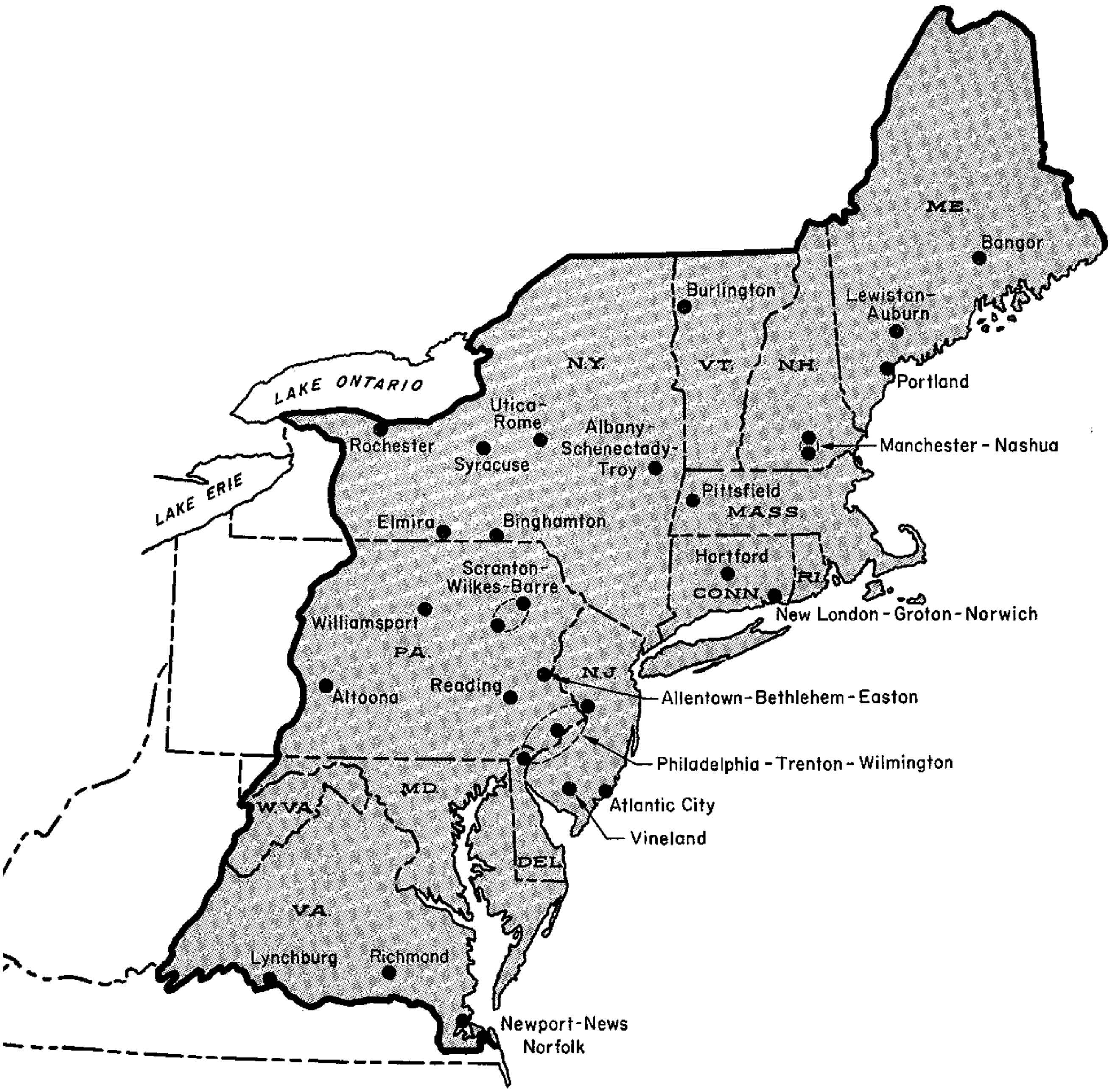
Early analyses of the 28 Standard Metropolitan Statistical Areas and the 4 projected SMSA's resulted in the delineation of 26 urban metropolitan areas for further study.

These 26 UMA's are situated within 11 of the 13 NEWS Study states, as shown on Figure 1. They had a total 1965 population of 11.3 million, about 23 percent of the 1965 NEWS Study Area total. By 2020, the populations of these UMA's are projected to increase to 21.7 million and represent about 26 percent of the NEWS Study Areas projected 2020 population. The UMA's have a combined area of some 10,500 square miles, about 5 percent of the entire NEWS Study Area. A total of 103 major water supply utilities (generally providing 1 mgd or more) are located in the selected 26 UMA's. There are also an estimated 400 suppliers which provide less than 1 mgd.

An urban metropolitan area is an integrated economic and social unit with a population greater than 50,000, comprising a central city and outlying areas. Its boundaries contain fringe areas whose densities may be expected to approach 1,000 per square mile. For the purposes of this study, a UMA is a water service area which is potentially amenable to regionalized water supply.

Generally, the selected UMA's are within the original SMSA's. In several instances, however, UMA's were delineated from contiguous SMSA's. The UMA's derived from SMSA combinations include Manchester-Nashua in New Hampshire, Hartford (combined Hartford, New Britain and Bristol SMSA's) in Connecticut, Scranton-Wilkes-Barre (combined Scranton and Wilkes-Barre-Hazelton SMSA's) in Pennsylvania, and Philadelphia-Trenton-Wilmington in the four states of Pennsylvania, New Jersey, Delaware and Maryland. Table 1 shows the state locations of the selected UMA's and illustrates the SMSA-UMA relationship.

It must be recognized that for any group of projections concerning population, water demands, and even the subsequent water deficits, a broad range of projections should be considered in developing projects with the flexibility necessary to handle most, if not all, possible situations. Such a range of projections



URBAN METROPOLITAN AREAS

FIGURE 1

TABLE I

DERIVATION OF URBAN METROPOLITAN AREAS

	SMSA	UMA
Maine	Bangor 1/ Lewiston-Auburn Portland	Bangor Lewiston-Auburn Portland
New Hampshire	Manchester Nashua	Manchester-Nashua
Vermont	Burlington 1/	Burlington
Massachusetts	Pittsfield	Pittsfield
Connecticut	New London-Groton-Norwich New Britain Hartford	New London-Groton-Norwich Hartford
New York	Albany-Schenectady-Troy Utica-Rome Syracuse Rochester Binghamton 2/ Elmira 1/	Albany-Schenectady-Troy Utica-Rome Syracuse Rochester Binghamton Elmira
Pennsylvania	Scranton Wilkes-Barre-Hazelton Williamsport 1/ Altoona Allentown-Bethlehem-Easton Reading Philadelphia 3/	Scranton-Wilkes-Barre Williamsport Altoona Allentown-Bethlehem-Easton Reading
Delaware	Wilmington 4/	Philadelphia-Trenton-Wilmington
New Jersey	Trenton Atlantic City Vineland	Atlantic City Vineland
Virginia	Lynchburg Richmond 5/ Newport-News-Hampton Norfolk-Portsmouth	Lynchburg Richmond Newport-News Norfolk

1/ Not SMSA's as of 1970 Census; anticipated to be SMSA's by 2020.

2/ Shared with Pennsylvania

3/ Shared with New Jersey

4/ Shared with Maryland and New Jersey

5/ Includes cities of Petersburg, Colonial Heights, and Hopewell for purposes of this study are also a consideration in the risks assumed or the margin of safety developed in establishing any construction completion date.

The single value of the projections contained in this study represents the median of the respective elements, and the assumptions and judgments made during the course of this study. These statistics, at best, are preliminary and thus subject to change. They have only been used as tools in formulating regional opportunities, and could be adjusted at any stage of the NEWS Study.

POPULATION

Population projections for each UMA are based on demographic data originated by the Office of Business Economics (OBE), U.S. Department of Commerce. OBE prepared an economic base for the North Atlantic Regional Water Resources Study that presented historical and projected economic and demographic information for the following areas: Entire United States, New England, the North Atlantic Region, States or portions of States in the North Atlantic Region, and North Atlantic Region water resources planning areas.

Obviously, by using a nationally and regionally controlled base, the projections in this report must fit within the framework of the whole. Projections made by others not so bound may differ from the projections based on the OBE data.

Table 2 contains summarized population data, grouped regionally, to facilitate presentation. This table reflects a 1970 population range from 57,000 in the Pittsfield UMA, to more than 5 3 million in the Philadelphia-Trenton-Wilmington UMA -- a range of nearly two orders of magnitude. Projections for 2020 indicate that the populations of these two UMA's will remain smallest and largest, with respective populations of about 68,000 and 8.8 million

The trends toward "urban sprawl" were especially brought out in the population studies for the UMA's. Between the censuses of 1950 and 1960, 20 of 43 central cities in the 32 SMSA's had increases in their population, and the remaining 23 lost population.

TABLE 2
POPULATION DATA
(Values in Thousands)

UMA	1960	1970	1980	2000	2020
		NEW ENGLAND			
Bangor	72.6	69.7	74.6	87.3	102.0
Lewiston-Auburn	70.3	72.5	73.8	84.7	93.3
Portland	142.2	146.5	156.0	180.0	213.0
Manchester-Nashua	159.6	200.3	225.0	360.0	426.0
Burlington	65.0	82.6	109.5	145.4	172.3
Pittsfield	57.9	57.0	59.0	63.5	68.1
New London-Groton-Norwich	131.2	159.0	182.0	227.0	270.1
Hartford	713.9	850.9	984.5	1,241.9	1,386.6
Total New England	1,412.7	1,638.5	1,864.4	2,389.8	2,731.4
		NEW YORK			
Albany-Schenectady-Troy	607.9	659.6	743 6	971.1	1,150.6
Utica-Rome	320.5	328.0	389 0	480.0	636.5
Syracuse	480 3	539.2	600.9	760 9	940 3
Rochester	586.4	711.9	897 0	1,052.0	1,318 0
Binghamton	200.3	207.6	246.0	314 5	398.0
Elmira	116.8	117.9	135.0	184.5	227.2
Total New York	2,312.2	2,564.2	3,011.5	3,763.0	4,670.6
		MIDDLE ATLANTIC			
Scranton- Wilkes-Barre	476.2	462.3	497.6	603.9	692.2
Williamsport	94.9	96.3	109.6	121.1	133.1
Altoona	107.6	106.5	117.0	139.0	155.5
Allentown-Bethlehem-Easton	415.0	452.0	491.0	584.4	667.8
Reading	228.1	239.3	252.0	308.0	379.0
Philadelphia-Trenton-Wilmington	4,842.0	5,384.0	5,877.0	7,311.0	8,798.0
Atlantic City	122.3	129.5	135.5	185.5	229.0
Vineland	87.9	100.4	120.0	152.0	186.0
Total Middle Atlantic	6,374 0	6,970.3	7,599.7	9,404.9	11,240.6
		VIRGINIA			
Lynchburg	82.7	86.5	90 0	103.0	115.0
Richmond	400.0	511.3	637.3	862.6	1,113.9
Newport News	201 4	261 5	340.0	455.0	585.0
Norfolk	520.0	668.3	769.0	983.0	1,230.0
Total Virginia	1,204.1	1,527.6	1,836.3	2,403.6	3,043.9

Between the 1960 census and that of 1970, however, only 12 increased while 31 decreased in population. Nevertheless, these tables reveal that between 1960 and 1970, 22 of the UMA's gained a total population of over 1.4 million, while the remaining four lost population amounting to only 19,000. The significance of these trends is covered in the section of this chapter on water demands.

It should be noted that this is not a definitive demographic study. The population predictions serve only as a means to an end for projecting water demands. Comparative examples of projections made by others are presented in Chapter 4. However, projections made by others in every UMA studied were considered carefully in arriving at the figures presented here.

WATER DEMANDS

Chapter 4 provides the details of the methodologies and assumptions used in projecting municipal and industrial (M & I) water demands. Three steps were followed in developing these projections: (1) Projections based on historic trends of domestic, commercial and publicly-supplied industrial water, (2) projections of total industrial water, and (3) modification of the results in the first step for some of the UMA's.

The first step was accomplished using a regression equation developed for the North Atlantic Regional Water Resources Study, which was selected because it has the following features that appeared to best serve the purposes of this study:

1. It is a modern technique that takes advantage of general historic trends of water use (domestic, commercial, and publicly-supplied industrial water).

2. It has a tested range of applicability throughout the NEWS Study Area.

3. It requires only a single recent base year for which population, water use, and per capita income data are simultaneously available.

4. It provides projections based on parameters of population and per capita income, both readily projected, and logically associated with water use.

In the second step, projections of total industrial water were made using the methodology developed for the August 1969 NEWS Study Report on "Alternative Regional Water Supply Plans for Northern New Jersey - New York City - Western Connecticut Metropolitan Area" as described in the Methodologies chapter.

Finally, the projections of Step One were accepted or modified by the results of Step Two and an analysis of the expected yield of fresh water sources available to the UMA for development. Essentially, the problem resolved in this analysis was whether sufficient fresh water was anticipated to be available in each specific UMA to expect industry to supply itself in meeting the projected increased demands, whether industry would be dependent to the same degree as it has in the past on publicly-supplied water, or to a greater degree in the future.

Industrial water use data are rather limited, either as separate statistics and compilations or as a part of published water supply plans. The methodologies used here to project industrial water demands seem to offer at least plausible results for preliminary planning.

Most plans reflect the amount of publicly-supplied industrial water for the base year of the plan. The difference between total M & I water use and publicly-supplied industrial water represents domestic water. Table 3 contains the domestic water demand projections.

Table 4 contains the publicly-supplied industrial water projections, and Table 5 shows the self-supplied industrial water projections. When combined, the data in these two tables reflect the total industrial water demands for each UMA summarized in Table 6. Combining the data presented in Table 3 with the data presented in Table 4 results in the total M & I water demands, summarized in Table 7.

All of the UMA's reflect increasing demands for M & I water supply ranging from 50 percent for Pittsfield UMA to 450 percent for Elmira UMA to the year 2020. The average increase for all 26 UMA's is nearly 200 percent.

TABLE 3
DOMESTIC WATER DEMANDS
(m. g. d.)

UMA	Mid 1960's	1980	2000	2020
NEW ENGLAND				
Bangor	6.7	8.6	11.6	15.9
Lewiston-Auburn	5.7	7.3	9.7	12.7
Portland	18 5	24.2	32.3	44.8
Manchester-Nashua	16.3	26 0	45.4	61.9
Burlington	4.0	6.9	10.3	14 4
Pittsfield	6.5	7.7	9.5	12.0
New London Groton-Norwich	7.9	14.0	20 0	26.9
Hartford	54.0	83.0	121.0	153.0
Total New England	119.6	177.7	259.8	341 6
NEW YORK				
Albany-Schenectady-Troy	70.0	99 8	144.3	188.8
Utica-Rome	31.0	44.0	63.0	94.0
Syracuse	56.0	91.7	132.4	187.6
Rochester	77.0	101.2	148.1	212 2
Binghamton	17.0	25 7	37.7	54.6
Elmira	9.7	15.8	24.4	34.6
Total New York	260 7	378.2	549.9	771.8
MIDDLE ATLANTIC				
Scranton-Wilkes-Barre	58.0	77.4	108.3	143.2
Williamsport	6.5	13.4	17.6	23.2
Altoona	10.5	13.3	18 2	24.0
Allentown-Bethlehem-Easton	41.0	52.0	71.0	94.0
Reading	16.6	21.5	30.3	42.7
Philadelphia-Trenton-Wilmington	428 0	580.0	820.0	1,130.0
Atlantic City	20.1	25.9	39.6	55.6
Vineland	9.0	15.3	24.3	36.5
Total Middle Atlantic	589.7	798.8	1,129 3	1,549.2
VIRGINIA				
Lynchburg	6.5	10.0	13.5	17.5
Richmond	42.7	62.8	96.2	137.8
Newport News	17.0	28.0	42.0	63.0
Norfolk	52.0	78.8	115.2	165.2
Total Virginia	118.2	179.6	266.9	383.5

TABLE 4
PUBLICLY SUPPLIED INDUSTRIAL WATER DEMANDS
(m.g.d.)

UMA	Mid 1960's	1980	2000	2020
	NEW ENGLAND			
Bangor	0.5	0.6	0.8	1.0
Lewiston-Auburn	1.9	3.3	5.8	9.6
Portland	2.0	3.7	7.2	12.1
Manchester-Nashua	4.0	7.4	15.3	27.9
Burlington	2.0	2.6	3.7	5.5
Pittsfield	6.4	6.4	6.4	6.4
New London-Groton-Norwich	8.0	10.2	15.5	24.6
Hartford	30.0	35.0	50.0	75.0
Total New England	54.8	69.2	104.7	162.1
	NEW YORK			
Albany-Schenectady-Troy	23.0	24.2	39.0	61.0
Utica-Rome	15.0	16.0	19.0	30.0
Syracuse	28.0	28.0	33.0	51.0
Rochester	20.0	30.0	59.0	98.0
Binghamton	13.0	13.1	14.6	18.5
Elmira	3.0	10.0	20.0	32.0
Total New York	102.0	121.3	184.6	290.5
	MIDDLE ATLANTIC			
Scranton-Wilkes-Barre	30.0	33.0	43.0	57.8
Williamsport	3.5	5.0	7.4	10.8
Altoona	1.5	2.3	4.3	8.1
Allentown-Bethlehem-Easton	18.0	36.0	65.0	106.0
Reading	13.5	17.0	25.5	43.6
Philadelphia-Trenton-Wilmington	230.0	420.0	600.0	860.0
Atlantic City	0.0	0.0	0.0	0.0
Vineland	2.5	3.1	3.8	4.8
Total Middle Atlantic	299.0	516.4	749.0	1,091.1
	VIRGINIA			
Lynchburg	4.0	6.0	10.0	16.0
Richmond	33.3	39.8	59.0	84.3
Newport News	8.0	12.0	19.0	27.0
Norfolk	13.0	19.7	28.8	41.3
Total Virginia	58.3	77.5	116.8	168.6

TABLE 5
SELF-SUPPLIED INDUSTRIAL WATER DEMANDS
(m g.d.)

UMA	Mid 1960's	1980	2000	2020
NEW ENGLAND				
Bangor	18.7	22 1	27.9	36.5
Lewiston-Auburn	9.3	9.3	9.3	9.3
Portland	11.7	11.7	11.7	11.7
Manchester-Nashua	39.3	39.3	39.3	39.3
Burlington	5.8	5.8	5.8	5.8
Pittsfield	8.0	8.0	8.0	8.0
New London-Groton-Norwich	16.0	16.0	16.0	16.0
Hartford	50.0	55.0	62.0	76.0
Total New England	158.8	167.2	180.0	202.6
NEW YORK				
Albany-Schenectady-Troy	117.0	117.0	117.0	117.0
Utica-Rome	29.0	29.0	29.0	29.0
Syracuse	34.0	34.0	34.0	34.0
Rochester	82.0	82.0	82.0	82.0
Binghamton	7.0	7 0	7.0	7.0
Elmira	8.0	8.0	8.0	8.0
Total New York	277.0	277.0	277.0	277.0
MIDDLE ATLANTIC				
Scranton- Wilkes-Barre	12.0	12.0	12.0	12.0
Williamsport	5.0	5.0	5.0	5.0
Altoona	15.0	15.0	15.0	15.0
Allentown-Bethlehem-Easton	290 0	324.0	371.0	425.0
Reading	30.0	30 0	30.0	30.0
Philadelphia-Trenton-Wilmington	1,900.0	2,360.0	3.400 0	4,890.0
Atlantic City	2.0	2.5	3.0	4.0
Vineland	25.0	28.0	34.3	43.0
Total Middle Atlantic	2,279.0	2,776.5	3,870.3	5,424.0
VIRGINIA				
Lynchburg	29.0	32.0	33.0	41.0
Richmond	170.0	186.0	260.0	339.0
Newport News	20.0	23.0	33.0	44.0
Norfolk	19.0	26.0	40.0	55.0
Total Virginia	238.0	267.0	366.0	479.0

TABLE 6
TOTAL INDUSTRIAL WATER DEMANDS
(m g.d.)

UMA	Mid 1960's	1980	2000	2020
	NEW ENGLAND			
Bangor	19.2	22.7	28.7	37.5
Lewiston-Auburn	11.2	12.6	15 1	18.9
Portland	13.7	15.4	18.9	23.8
Manchester-Nashua	43 3	46.7	54.6	67.2
Burlington	7.8	8.4	9.5	11.3
Pittsfield	14.4	14.4	14.4	14.4
New London-Groton-Norwich	24.0	26.2	31 5	40.6
Hartford	80.0	90.0	112.0	151.0
Total New England	213.6	236.4	284.7	364.7
	NEW YORK			
Albany-Schenectady-Troy	140.0	141.2	156.0	178.0
Utica-Rome	44.0	45.0	48.0	59.0
Syracuse	62 0	62.0	67.0	85.0
Rochester	102.0	112.0	141 0	180.0
Binghamton	20.0	20.1	21.6	25.5
Elmira	11.0	18.0	28.0	40.0
Total New York	379.0	398 3	461.6	567.5
	MIDDLE ATLANTIC			
Scranton- Wilkes-Barre	42.0	45.0	55.0	69 8
Williamsport	8.5	10.0	12.4	15.8
Altoona	16.5	17 3	19.3	23.1
Allentown-Bethlehem-Easton	308.0	360.0	436.0	531.0
Reading	43.5	47.0	55.5	73.6
Philadelphia-Trenton-Wilmington	2,130.0	2,780.0	4,000.0	5,750.0
Atlantic City	2.0	2.5	3.0	4.0
Vineland	27.5	31.1	38.1	47.8
Total Middle Atlantic	2,578.0	3,292.9	4,619.3	6,515.1
	VIRGINIA			
Lynchburg	33 0	38.0	43.0	57.0
Richmond	203.3	225.8	319.0	423 3
Newport News	28.0	35.0	52.0	71.0
Norfolk	32.0	45.7	68.8	96.3
Total Virginia	296.3	344.5	482.8	647.6

TABLE 7
TOTAL M & I WATER DEMANDS
(m. g. d.)

UMA	Mid 1960's	1980	2000	2020
NEW ENGLAND				
Bangor	7.2	9.2	12.4	16.9
Lewiston-Auburn	7.6	10.6	15.5	22.3
Portland	20.5	27.9	39.5	56.9
Manchester-Nashua	20.3	33.4	60.7	89.8
Burlington	6.0	9.5	14.0	19.9
Pittsfield	12.9	14.1	15.9	18.4
New London-Groton-Norwich	15.9	24.2	35 5	51.5
Hartford	84.0	118.0	171.0	228.0
Total New England	174.4	246.9	364 5	503.7
NEW YORK				
Albany-Schenectady-Troy	93.0	124.0	183.3	249.8
Utica-Rome	46.0	60.0	82 0	124.0
Syracuse	84.0	119 7	165.4	238.6
Rochester	97.0	131.2	207 1	310.2
Binghamton	30.0	38 8	52.3	73.1
Elmira	12.7	25.8	44.4	66.6
Total New York	362.7	499.5	734.5	1,062.3
MIDDLE ATLANTIC				
Scranton- Wilkes-Barre	88.0	110.4	151.3	201.0
Williamsport	10.0	18.4	25.0	34.0
Altoona	12.0	15.6	22.5	32.1
Allentown-Bethlehem-Easton	59.0	88.0	136.0	200.0
Reading	30.1	38.5	55.8	86.3
Philadelphia-Trenton-Wilmington	658.0	1,000.0	1,420.0	1,990.0
Atlantic City	20.1	25.9	39.6	55.6
Vineland	11.5	18.4	28.1	41.3
Total Middle Atlantic	888.7	1,315.2	1,878.3	2,640.3
VIRGINIA				
Lynchburg	10.5	16.0	23.5	33.5
Richmond	76.0	102.6	155.2	222.1
Newport News	25.0	40.0	61.0	90.0
Norfolk	65.0	98.5	144.0	206.5
Total Virginia	176.5	257.1	383.7	552.1

The trend of central cities losing population to the surrounding suburban areas is significant to water supply, as the requirements for extending centrally-located distribution systems increase. Certainly, some new distribution systems are built where extensions of existing systems are impractical. As the service areas within a UMA coalesce, the extension of old and construction of new transmission facilities to the load centers must be kept ahead of the demands. The loss of customers in the central cities results in the loss of revenue while operation and maintenance costs mount with age of the existing facilities. Projected increases in per capita use will only partially offset the losses of revenue. Periodically, the central city could be expected to raise its rates to maintain itself. Perhaps planning should be directed toward locating industry or recreational facilities in the central cities to take advantage of the in-place utilities left by the exodus of people.

Logically, such trends point to the need for the possible regionalization of water supplies. Transmission construction and mass interconnections of distribution systems necessary to support the UMA become the critical concern of the engineer planner.

CAPACITY AND DEFICITS

A review of the plans for water supply together with data collected from many sources, such as planning agencies and water utilities, provided information on the present water supply capabilities of each UMA, which is presented in Table 8. This table presents gross capacities, which when compared to the total M & I water demands, reflect either a gross excess or gross deficit.

The determination of the capacity in each UMA was based on facilities development existent in the mid 1960's. Mid 1960's capacity was adjusted in 1980 for the Hartford, Rochester, Reading, and Newport News UMA's. Additional facilities are now under construction in these UMA's that are expected to be in service prior to 1980. Many plans, some of which were abstracted for this study, reflect future planned construction which would increase present capacities. These are evaluated elsewhere in

TABLE 8
M & I WATER SUPPLY DEFICITS

WATER DEMANDS VERSUS CAPACITY
(in mgd)

NEW ENGLAND

UMA	Mid 1960's	1980	2000	2020
Bangor				
Total M & I Demand	7.2	9.2	12.4	16.9
Capacity	11.8	11.8	11.8	11.8
Deficits	--	--	0.6	5.1
Lewiston-Auburn				
Total M & I Demand	7.6	10.6	15.5	22.3
Capacity	14.1	14.1	14.1	14.1
Deficits	--	--	1.4	8.2
Portland				
Total M & I Demand	20.5	27.9	39.5	56.9
Capacity	52.3	52.3	52.3	52.3
Deficit	--	--	--	4.6
Manchester-Nashua				
Total M & I Demand	20.3	33.4	60.7	89.8
Capacity	33.8	33.8	33.8	33.8
Deficits	--	--	26.9	56.0
Burlington				
Total M & I Demand	6.0	9.5	14.0	19.9
Capacity	12.0	12.0	12.0	12.0
Deficits	--	--	2.0	7.9
Pittsfield				
Total M & I Demand	12.9	14.1	15.9	18.4
Capacity	14.9	14.9	14.9	14.9
Deficits	---	--	1.0	3.5
New London-Groton-Norwich				
Total M & I Demand	15.9	24.2	35.5	51.5
Capacity	28.4	28.4	28.4	28.4
Deficits	--	--	7.1	23.1
Hartford				
Total M & I Demand	84.0	118.0	171.0	228.0
Capacity	122.6	177.0	177.0	177.0
Deficit	--	--	--	51.0

MIDDLE ATLANTIC

UMA	Mid 1960's	1980	2000	2020
Scranton-Wilkes-Barre				
Total M & I Demands	88.0	110.4	151.3	201.0
Capacity	145.0	145.0	145.0	145.0
Deficits	--	--	6.3	56.0
Williamsport				
Total M & I Demands	10.0	18.4	25.0	34.0
Capacity	17.4	17.4	17.4	17.4
Deficits	--	1.0	7.6	16.6
Altoona				
Total M & I Demands	12.0	15.6	22.5	32.1
Capacity	12.0	12.0	12.0	12.0
Deficits	--	3.6	10.5	20.1
Allentown-Bethlehem-Easton				
Total M & I Demands	59.0	88.0	136.0	200.0
Capacity	97.9	97.9	97.9	97.9
Deficits	--	--	38.1	102.1
Reading				
Total M & I Demands	30.1	38.5	55.8	86.3
Capacity	54.9	64.9	64.9	64.9
Deficits	--	--	--	21.4
Philadelphia-Trenton-Wilmington				
Total M & I Demands	658.0	1,000.0	1,420.0	1,990.0
Capacity	1,032.3	1,032.3	1,032.3	1,032.3
Deficits	--	--	387.7	957.7
Atlantic City				
Total M & I Demands	20.1	25.9	39.6	55.6
Capacity	52.6	52.6	52.6	52.6
Deficit	--	--	--	3.0
Vineland				
Total M & I Demands	11.5	18.4	28.1	41.3
Capacity	30.6	30.6	30.6	30.6
Deficits	--	--	--	10.7

TABLE 8 (Continued)
M & I WATER SUPPLY DEFICITS

WATER DEMANDS VERSUS CAPACITY
(in mgd)

NEW YORK

UMA	Mid 1960's	1980	2000	2020
Albany-Schenectady-Troy				
Total M & I Demands	93.0	124.0	183.3	249.8
Capacity	132.8	132.8	132.8	132.8
Deficits	--	--	50.5	117.0
Utica-Rome				
Total M & I Demands	46.0	60.0	82.0	124.0
Capacity	46.5	46.5	46.5	46.5
Deficits	--	13.5	35.5	77.5
Syracuse				
Total M & I Demands	84.0	119.7	165.4	238.6
Capacity	139.3	139.3	139.3	139.3
Deficits	--	--	26.1	99.3
Rochester				
Total M & I Demands	97.0	131.2	207.1	310.2
Capacity	120.0	190.0	190.0	190.0
Deficits	--	--	17.1	120.2
Binghamton				
Total M & I Demands	30.0	38.8	52.3	73.1
Capacity	93.0	93.0	93.0	93.0
Deficits	--	--	--	--
Elmira				
Total M & I Demands	12.7	25.8	44.4	66.6
Capacity	27.0	27.0	27.0	27.0
Deficits	--	--	17.4	39.6

VIRGINIA

UMA	Mid 1960's	1980	2000	2020
Lynchburg				
Total M & I Demands	10.5	16.0	23.5	33.5
Capacity	15.0	15.0	15.0	15.0
Deficits	--	1.0	8.5	18.5
Richmond				
Total M & I Demands	76.0	102.6	155.2	222.1
Capacity	120.0	120.0	120.0	120.0
Deficits	--	--	35.2	102.1
Newport News				
Total M & I Demands	25.0	40.0	61.0	90.0
Capacity	30.0	50.0	50.0	50.0
Deficits	--	--	11.0	40.0
Norfolk				
Total M & I Demands	65.0	98.5	144.0	206.5
Capacity	90.5	90.5	90.5	90.5
Deficits	--	8.5	53.5	116.0

the study. The deficits shown would be reduced accordingly, if and when such plans are actually implemented.

Unless the combined systems were suitably interconnected, the full capability of the systems could not be realized. Consequently, local deficits could occur sooner and the amount could exceed that shown in this table. Thus, the results shown can be considered minimum deficits.

Table 9 summarizes these gross deficits for each benchmark year. Deficits first appear in five of the UMA's by 1980, and in fifteen more by 2000. Five UMA's do not show any deficits until 2020; and one has no deficit appearing during the study period. The cumulative total deficits also are shown in Table 9 for each benchmark year.

TABLE 9

SUMMARY OF WATER SUPPLY DEFICITS

	1980			2000			2020		
	Deficits first appearing in 1980			Deficits first appearing in 2000			Deficits first appearing in 2020		
Region	Number of UMA's	Deficits (in mgd)	Cumulative total deficits (in mgd)	Number of UMA's	Deficits (in mgd)	Cumulative total deficits (in mgd)	Number of UMA's	Deficits (in mgd)	Cumulative total deficits (in mgd)
New England	--	--	--	6	39.0	39.0	2	55.6	159.4
New York	1	13.5	13.5	4	111.1	146.6	--	--	453.6
Mid-Atlantic	2	4.6	4.6	3	439.7	450.2	3	35.1	1,187.6
Virginia	2	9.5	9.5	2	46.2	108.2	--	--	276.6
Totals	5	27.6	27.6	15	636.0	744.0	5	90.7	2,077.2

The significance of these deficits is covered in detail in Volume II, Area Reports. Considering that normal planning and construction for water supply will provide capacity to meet needs about 15 to 25 years in advance, it does not seem unreasonable that most of the UMA's have deficits appearing by 2000. Those UMA's with deficits not appearing until 2020 are in an especially favorable position, while those expecting deficits within 10 years may have cause to be concerned in the immediate future.

The relative magnitude of the deficit when compared with the total demand is particularly significant. For the five UMA's for which deficits are indicated by 1980, the ratio of the deficit to the demand expressed as a percent is given in Table 10 below.

TABLE 10

RELATIVE MAGNITUDE OF DEFICITS (1980) TO

TOTAL M & I WATER DEMANDS FOR SELECTED UMA'S

UMA	Percent
Altoona	23.1
Utica-Rome	22.5
Norfolk	8.6
Lynchburg	6.3
Williamsport	5.4

Finally, it is necessary to examine the specific situation in each of these UMA's to determine the nature of the problem and consider whether the problem is critical. The problems in these five UMA's are briefly outlined below:

1. Altoona UMA -- the limiting factors are inadequate transmission and pumping facilities and inadequate treatment capacity during times of high runoff; the safe-yield of developed sources is estimated to be 60 mgd.

2. Utica-Rome UMA -- the limiting factor is treatment facilities. Both Utica and Rome are continuing to supply water from surface sources to their present service area, without providing treatment required by the state.

3. Norfolk UMA -- the limiting factor is locating the most reasonable source for development; present local sources are fully utilized and the area is confronted with the need to import water from increasing distances or seriously consider reuse of wastewater.

4. Lynchburg UMA -- the limiting factors are treatment capacity and transmission facilities; additional sources are available but would require additional development.

5. Williamsport UMA -- the limiting factors are treatment and transmission, although additional sources must be developed to meet the 2020 demands. The Williamsport Municipal Water Authority is now expanding its reservoir capacity by about 2 mgd, which should meet the 1980 demand.

From an engineering point of view, the problems of Altoona, Lynchburg, Utica-Rome and Williamsport seem more readily solved than for Norfolk. Obviously, from a social or economic point of view, the solution of any of these could prove to be critical for the particular UMA. Weighing these aspects, the following priority order of criticality seems logical:

Priority	UMA
1	Norfolk
2	Altoona
3	Utica-Rome
4	Lynchburg
5	Williamsport

CHAPTER 3. REGIONALIZATION

In the early 1960's, most of the Northeastern United States was affected severely by a drought. Many communities suffered acute hardships: some because emergency measures, such as utilizing tank trucks and hastily-laid pipe lines to assist water-starved areas, were inefficient; others because they were handicapped by inadequate connections in their attempts to receive aid from their neighbors. If the extended consequences of a drought had been considered in the plans and designs of water supply systems, provisions for interconnecting facilities with those of neighboring communities may have averted the disastrous water shortage.

Almost every urban metropolitan area considered in this study was found to have several water utilities, but, like many other metropolitan areas, only a few have made physical interconnections. Regional planning for water supply, however, was found to be a trend in all the areas of the Northeast.

Population explosion, suburbanization around core cities, and industrial expansion have overtaxed local planning and, as a result, the construction of water supply facilities. In the case of smaller utilities, developing new sources or increasing the yield of present sources may be uneconomical, or even physically impossible. They may be able to continue to supply a fixed number of customers for many years. They will eventually deplete their local sources or induce shortages, however, if they attempt to provide service to a greater number of customers.

Regionalization is a broad term, and its implications are extensive. In the UMA study, a regional water supply is a system which has the sources and facilities to serve adequately two or more municipalities; and which results from the integration of any one, or any combination, of the plans, designs, construction, management, or interconnected facilities of smaller systems. The potential for a regionalized supply system exists in all of the UMA's, since each contains at least two municipalities and water utilities. The extent to which this potential has been implemented, however, varies; some areas already are served by one integrated system, while others are just beginning to consolidate plans or services.

How appropriate to a given area regionalization may be is determined by its affects on the environment, socio-economic bases, reliability of consolidated systems, and efficiency of sources and management.

There exist no limits to the size or location of potential water supply areas when considering a regional system; however, a logical approach is to seek local sources first, and to expand to greater distances later. Therefore, once an urban metropolitan area was judged feasible, in this study, to accommodate regionalization, the exploration for resources progressed from the local watersheds, to the major river basin, and finally to inter-basin transfer. The progression can be carried to grandiose proportions, so that even transporting water from the Yukon to supply the arid Texas-Arizona region is not inconceivable. Of prime importance in determining whether a source, local or distant, can be utilized, are the physical aspects of the water supply--quantity, quality, storage, pumping, treatment and transmission.

EVALUATING UMA WATER SUPPLIES

A comprehensive evaluation of the water supply situation of each of the designated UMA's was prepared by adhering to five procedures:

- Categorizing the existing water supplies as regional or non-regional;
- Determining the adequacy of the existing systems, and their plans for the future, in meeting the anticipated water demands;
- Determining the desirability for greater regionalization, assuming an increase of the potential to meet demands (or preclude deficits), to conserve resources, or to effect greater economy.
- Suggesting alternative developments of water supply; and,
- Establishing an order of technological practicality to all of the opportunities for water supply, and placing them within the

time periods before and after 1990, or at benchmark years 1980, 2000 or 2020.

The derivation of the evaluation procedures is explained in the section in Chapter 4 "Basis of Analysis for Regional Water Supply."

The nature of this study is such, however, that only minimal consideration has been afforded the solutions of problems peculiar to a local unit within a particular UMA. It was felt that those problems could be most suitably corrected locally.

SUMMARY OF REGIONALIZATION

Many UMA's were found to have a framework for a regional system. In such instances, either a planning organization to consider the possibility of consolidating the water supply of the UMA exists; or legislative action has been implemented to establish one. Included for consideration are the merits of collective management, and the physical problems of effecting a regional water supply. Occasionally, however, political, economic or institutional restraints within certain UMA's impair the designs for regionalization. When made known, the restraints are identified; but they have been disregarded when the desirability for regionalization and alternatives for development have been proposed. It would not be reasonable to eliminate from consideration a feasible suggestion for water supply, merely on the basis of a constraint which might be amended.

CHAPTER 4. METHODOLOGIES

The initiation of a planning effort with the magnitude of scope and the variety of locations involved in the Preliminary Study of the Long-Range Water Supply Problems of Selected Urban Metropolitan Areas, required the careful and detailed development of a plan of study, or procedural guidelines for directing the project.

The four major sections in this chapter -- Regional Water Supply Analysis, Water Deficits, Analysis of Water Availability, and Cost Estimates were developed at the initiation of the study as basic guidelines for the conduct of the study and the development of the report. While they were followed for the most part as the study progressed, there are some items that were not utilized fully because they would have led to analyses that would have gone beyond the scope of this preliminary study, and in some instances, these methodologies were amended as the study progressed. They have been reproduced in full, however, because they serve as a guide to a complete understanding of the procedures used in the preparation of this report, and might be of benefit in possible future, more-detailed studies of the areas or data covered in this study.

REGIONAL WATER SUPPLY ANALYSIS

The primary objective of the NEWS Study is to prepare plans for adequate water supplies for the urban metropolitan areas of the Northeast. Planning water supplies to serve these large areas, represents a challenge as well as a problem to those concerned -- the development of water supply in sufficient quantity, of high enough quality, and without any further damage to the environment, are not problems to be solved overnight.

It is therefore imperative, before embarking on any course of action, to take stock of the existing situation through intensive analysis. Water is not evenly distributed in America, nor is it naturally concentrated in those areas having the greatest requirements. Uncoordinated water supply development, either in concept or method, will not solve long-range water supply problems.

The UMA Study has raised some major questions and developed detailed reasoning leading to a logical choice of regionalization of water supply as an adjunct to such high population density. Each area, however, is an individual case, and therefore regionalization should not be the predetermined solution until proper evaluation has been made of all possible current and future cause and effect relationships.

THE ANALYSIS

Four steps are necessary in making a thorough analysis of the potential for regionalizing water supplies. They are

1. Examination of the existing water supply situation,
2. Evaluation of the capabilities of the existing planning efforts to achieve desired goals.
3. Determination of the applicability of regionalization for each urban metropolitan area, and
4. Examination of the opportunities that are available for regionalizing water supplies, when it appears desirable in effecting more efficient operation in the attainment of necessary goals.

A full description of the procedures involved in evaluation of these four major points follows

Existing Water Systems

<u>Total Capacity</u>. Determination of the total capacities of the sources, treatment plants, pumping facilities and transmission mains of major systems.

<u>Total Deficits</u>. Based on projected water demands, determination of the deficit in total system capacity for appropriate time periods as pertaining to sources, treatment plants, pumping facilities, and transmission mains.

Degree of Regionalization. Determination of the degree to which the existing systems fulfill a regional concept for water supply. The following questions should be answered in analyzing the potential for regionalization.

System Size -- Is the UMA served by several small systems, a few large systems, or a combination of large and small systems?

Interconnections -- Are any of the systems interconnected?

Joint Sources -- Are any water sources used by several water utilities?

Management Status -- Does a collective management exist?

Regionalization -- Are systems amenable to regionalization?

Existing Plans

In evaluating the current efforts of all planning agencies which have responsibilities in the UMA, the following five considerations should be made.

Comparison of UMA Data with Existing Plans. Compare the projections of this study (population and water demand) with those of the existing plans.

Comparison of Plans with Needs. Determine the future capacities provided by the existing plans -- will the plans satisfy the 2020 or other bench mark year needs? Consider the possible abandonment of facilities (treatment, pumping, transmission) which may be obsolete by 2020.

Regional Concept of Plans. Are the existing plans regional in concept -- can they be expanded to effect regionalization of water supply?

Cost of Planned Projects. Extract or calculate the estimated construction cost of the projects included in existing plans.

Status of Plans. Contact involved local and regional officials to determine the present implementation status of the existing plans.

Applicability of Regionalization

Factors to Consider. There are several factors which bear on the possible application of regionalization to the water supply systems in a UMA. The factors which must be considered are:

Future Deficits -- The existence of large future deficits (source, treatment, pumping, transmission). The deficits should also be sized in relation to total system capacities.

Facilities Expansion Limitations -- Expansion of existing systems which will not accommodate projected deficits.

Inadequacy of Plans -- Proposed local plans in a UMA which are inadequate for meeting projected needs.

Inefficient Use of Resources -- Inefficient utilization of water resources and/or financial resources designated for water resource development.

Shortage of Resources -- Non-availability of economically-feasible local resources.

Reliability of Sources -- Reliability of quantity or quality of existing and projected sources.

Expanding Economic Base -- Desirability of developing a broader base pertaining to parameters such as economics and administration.

Evaluation Conclusions. Based on these factors, the evaluation of each UMA, with regard to accomplishing efficient water utilization for meeting 2020 water supply demands, will result in one of the following conclusions:

- No additional water supply development, or modification to existing supplies are necessary--present plans are adequate.

- Relatively minor modifications to existing plans are necessary.

- Regionalization must be given full consideration.

Regionalization Opportunities

In an evaluation of the feasibility of opportunities for regionalizing water systems, it is imperative that all potential sources are identified, yields analyzed, and alternative plans developed.

Identification of Sources. In identifying feasible sources, the following should be considered·

Groundwater -- Available groundwater within close proximity to, or outside the UMA.

Surface Water (Class A, B, or C) -- Available within the UMA, or outside the UMA within the major river basin in which the UMA is located. (Class C water will require heavy treatment.)

Other Sources -- Water which can be made available through interbasin transfer, the reclamation and reuse of wastewater, or the eventual desalting of brackish water or seawater.

Yield. Evaluate the safe yield or possible developable yield from sources identified, noting any water quality problems as they affect the availability or feasibility of a source. If a source has multiple uses, consider only the allocation available for water supply as opposed to allocations reserved for other uses such as low-flow maintenance or hydroelectric power.

Groundwater -- Search available literature for estimates of aquifer yield and/or consult local officials.

Surface water -- Obtain rough estimates of storage by any of the generally accepted techniques.

Alternative Plans. Generate reasonable alternative plans for supplying the UMA's, considering the following

Adequate Sources -- List plans of single sources and/or combinations which will supply the required projected deficits that appear feasible.

Required Facilities -- Indicate the necessary accompanying facilities (treatment, pumping, transmission) for each alternative plan, including estimates of required design capacities, approximate locations of plants and transmission lines, and necessary modifications to existing facilities, institutional, or managerment arrangements.

Evaluate Opportunities -- Make an evaluation of opportunities to include practicality based on present technology, time of need, socio-economic impact, environmental impact, compatability with regional water resources plans, and costs based on relative order of magnitude.

WATER DEFICITS

Several steps are necessary in determining the water deficits of an urban metropolitan area after its boundaries are determined and its characteristics have been described. First, determine its present and projected future population; second, determine its present and projected water demands, both for publicly supplied municipal and industrial (M & I) and privately supplied industrial (PI) water; third, determine the present supply capacity (to include construction underway); and fourth, determine the water deficit of the UMA by obtaining the difference between projected demands and present capacity.

POPULATION PROJECTIONS

Past and present populations of each UMA were obtained by disaggregation of census data, including 1970.

Projections of populations for this study are primarily based on the findings and projections contained in Appendix B, NAR Study (Economic Base), Part I of which was prepared by the Office of Business Economics (OBE) of the U.S. Department of Commerce for use in water and related land resource development planning. The OBE population projection, as with other economic divisions in the OBE Study, was designed to "provide a large, but not complete, segment of the data needed." Its national projection of the overall economic picture was disaggregated to economic areas and further to local areas and then reassembled into water resource planning areas. In addition, the Corps of Engineers provided projections, also based on the OBE data, for each SMSA.

In order to satisfy the need for population projection data of this long-range study, as it is related to water resource planning, but on the scale of the assessed metropolitan areas here, some modifications were necessary of the affected over-all national economy OBE data. The main source of information for the purpose of the necessary modification was the 1970 census. The census data were used to modify SMSA projections because the SMSA represented a more suitable scale for this study.

Census data for various components of each UMA defined were aggregated for 1970 and the previous decades. A ratio of populations for 1970 between each UMA and its corresponding SMSA was used in projecting the 1980, 2000, and 2020 populations.

Results of these projections are summarized in Table 2 p. 9.

Differences may be noted when comparing these projections with those done by others. The important aspect, however, is that populations of the 26 UMA's have been projected by a uniform methodology related directly to the United States, the NAR Water Resources Study Area, and components of the latter area. Thus, a balanced interrelation is maintained among all of the UMA's. These projections serve as the population base for all other projections in this study.

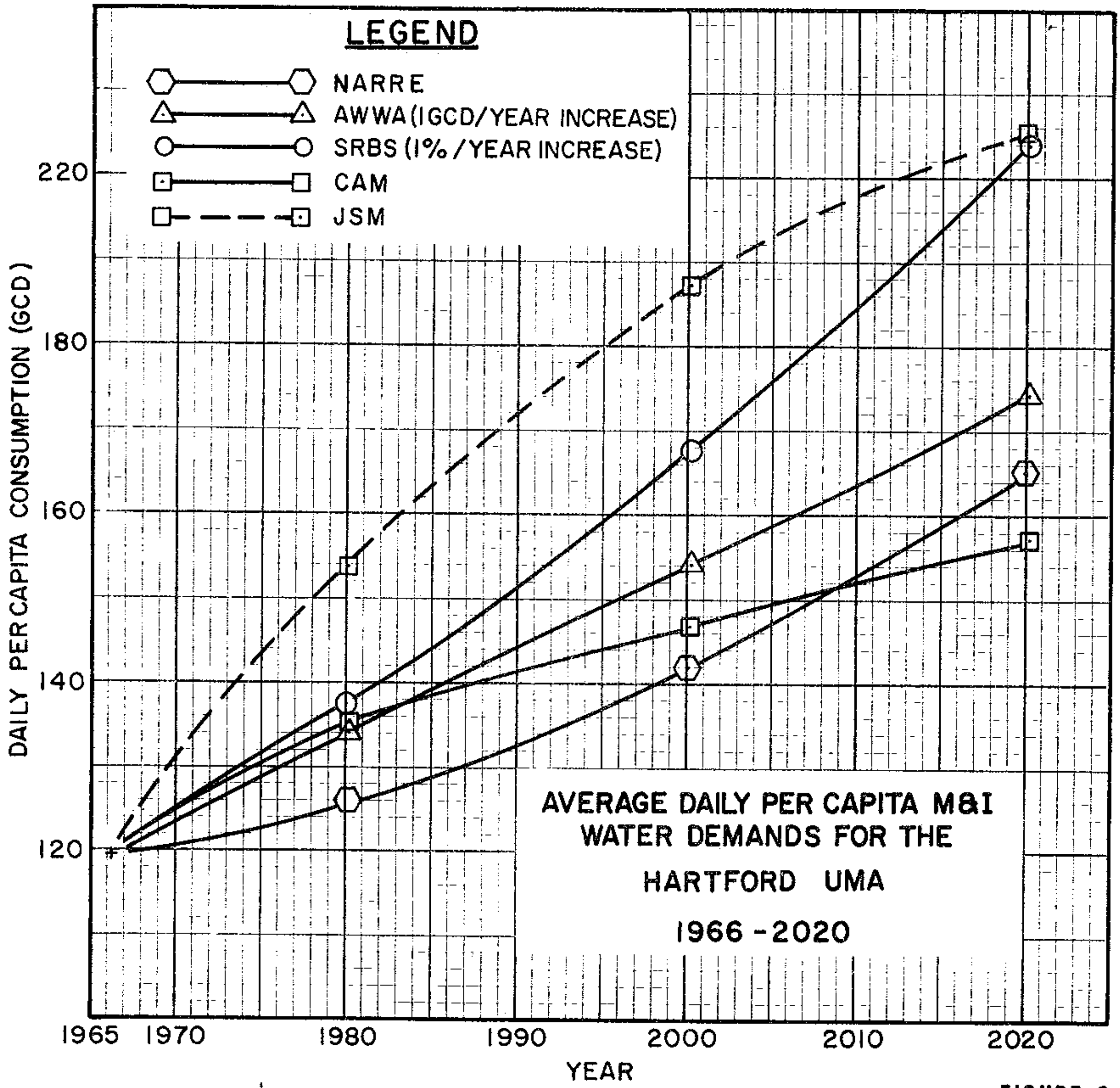
PUBLICLY SUPPLIED WATER DEMAND PROJECTIONS

Five techniques for projecting publicly supplied water demands were reviewed intensively for use in this study

1. American Water Works Association (AWWA)
2. NAR Regression Equation (NARRE)
3. Charles A. McGuire & Associates (CAM)
4. James S. Minges & Associates (JSM)
5. Susquehanna River Basin Study (SRBS)

In order to forecast future water demands, all of these techniques need the following basic data: population served by public supply -- base year, 1980, 2000, and 2020, and total M & I water supplied in the base year. In addition, the NARRE method also requires per capita income -- base year, 1980, 2000, and 2020.

Figure 2 shows the variations in projections of average per capita M & I water demands among the five techniques reviewed for the same UMA.



Anderson-Nichols & Co. Inc

FIGURE 2

The NARRE method was selected for use in this study because it best relates to the population data available with reasonable results - neither extremely high or low when compared with the other techniques reviewed. The technique is developed on OBE based population and personal income data.

Total personal income data for each SMSA was provided by the Corps of Engineers derived from OBE data. These data were divided by the OBE - based population values to obtain per capita income. Table 11provides the results at the SMSA level for the original 32 SMSA's considered in this long-range study. Because a large portion of the SMSA populations reside within the boundaries of the UMA's, the SMSA per capita income also is assumed representative of the UMA. The base year per capita income was derived by interpolation for each SMSA.

The NAR Regression Equation provided by the Corps of Engineers is of the form·

$$C_{n,i} = A_n \ (P_{n,i})^a \ (Y_{n,i})^b$$

where:

$C_{n,i}$ = Total publicly supplied water demand for area n, year i

A_n = Constant for area n, calculated from existing data

$P_{n,i}$ = Population served in area n, year i

$Y_{n,i}$ = Per capita income for area n, year i

a = 0.825, exponential developed from Connecticut data

B = 0.308, exponetial developed from Connecticut data

a and B are coefficients developed from Connecticut data and are considered applicable to the entire NEWS region by the Corps of Engineers. A_n is an areal constant obtained from present data (1965 assumed as base year) from the equation·

$$A_n = \frac{C_{n,\ 1963}}{(P_{n,\ 1965})^a \ (Y_{n,\ 1965})^B}$$

Knowing A_n, one can then solve for the values $C_{n,}$ 1980; $C_{n,}$ 2000; and $C_{n,}$ 2020 using projected values of $P_{n,i}$ and $Y_{n,i}$ for i = 1980, 2000, and 2020.

TABLE 11

PER CAPITA INCOME 1/
SMSA's

SMSA	1960	1980	2000	2020
Bangor, Me.	1543.70	3054.70	5396.20	9759.90
Lewiston-Auburn, Me.	1923.10	3626.50	6330.80	11655.20
Portland, Me.	2117.10	3621.20	6329.30	11660.50
Manchester, N.H.	2323.00	4110.30	7160.50	12410.10
Nashua, N.H.	2323.00	4110.30	7160.50	12410.10
Burlington, Vt.	1946.20	3314.50	5849.00	10535.80
Pittsfield, Mass.	2279.00	4536.90	7608.00	13038.40
New London-Groton-Norwich	2460.80	4543.80	7612.30	13042.70
Hartford, Conn.	2770.80	4504.70	7617.40	13200.30
New Britain, Conn.	2770.80	4504.70	7617.40	13200.30
Bristol, Conn.	2770.80	4504.70	7617.40	13200.30
Albany-Schenectady-Troy	2267.60	4111.90	7160.80	12410.40
Utica-Rome, N.Y.	2107.00	3961.40	6921.60	12183.90
Syracuse, N.Y.	2167.80	3962.10	6920.90	12184.80
Rochester, N.Y.	2613.90	4240.10	7158.20	12595.20
Binghamton, N.Y.-Pa.	2125.50	3823.80	6802.50	12037.90
Elmira, N.Y.	2125.50	3823.80	6802.50	12037.90
Scranton, Pa.	1791.00	3619.60	6418.80	11542.40
Wilkes-Barre-Hazelton, Pa.	1717.50	3620.10	6421.40	11536.80
Williamsport	1741.30	3297.80	6222.70	11695.70
Altoona, Pa.	1798.90	3620.10	6414.60	11535.30
Allentown-Bethlehem-Easton	2231.20	4029.60	7160.80	12408.80
Reading, Pa.	2200.40	4028.70	7157.20	12415.00
Philadelphia, Pa.-N.J.	2476.60	4387.60	7411.20	12776.50
Wilmington, Del.-Md.-N.J.	2786.40	4389.70	7410.90	12775.10
Trenton, N.J.	2623.80	4386.60	7403.60	12759.80
Atlantic City, N.J.	1951.50	4380.40	7397.60	12749.30
Vineland, N.J.	2207.60	4393.80	7562.20	12803.10
Lynchburg, Va.	1716.30	3279.00	5864.60	10538.60
Richmond, Va.	2368.70	3757.20	6558.50	11401.20
Newport News-Hampton, Va.	2039.10	3940.70	7024.80	12432.40
Norfolk-Portsmouth, Va.	1868.60	3941.80	7023.50	12436.00
National Average	2160.60	4112.00	7162.00	12411.00

1/ Based on the 1958 dollar. Source: OBE.

Application of the NAR Regression Equation to each UMA resulted in projections of publicly supplied water (combined domestic and publicly supplied industrial water) for 1980, 2000, and 2020. Further refinement of these projections is deferred here until the total industrial water demand methodology has been presented.

INDUSTRIAL WATER DEMAND PROJECTIONS

Historically, water for industrial purposes has been supplied from both publicly and privately owned sources. Until 1954, little data had been collected on industrial water usage. Since then, the U.S. Bureau of Census has made periodic surveys and published the results for 1954, 1958, 1963, and 1967 (only a small portion of the latter had been released by April 1971). Because of the statutory requirement to maintain a confidential relationship with the industrial constituents of the Census, the published data lack sufficient detail to pinpoint precisely many areas and their associated quantities of water used. However, methodologies have been developed for estimating present and future use of water by industry.

The NAR Regression Equation provides one means of projecting municipal and industrial water, though it does contain an implied assumption that the future will follow the historical trend of water supplied to industry. Considering only the geographic extent of metropolitan areas, the opportunities, in general, for future development of water sources therein by private industry will rapidly diminish. The expansion of urban metropolitan areas will reduce the number of potential well sites within the UMA's. Nearby surface water bodies will become recreational facilities, if not already appropriated for local domestic water supply. But industry, located in proximity to its work force, can usually obtain suitable water from public supplies, providing that the planners have properly considered this important need. Therefore, finding a method to project future industrial demands based on the growth trends of industry seemed most appropriate.

The NEWS Group, Corps of Engineers developed a methodology for determining total industrial water demands (NEWS methodology). It was first presented by Robert H. Stewart of Hazen and Sawyer in a paper entitled "Industrial Water Forecasts" at the AWWA Annual Conference in Washington, D.C., on June 23, 1970. This methodology was adopted for use in this study.

Determination of Projection Factors

To facilitate an understanding of this NEWS methodology in arriving at the total industrial water use in each UMA, the Projection Factor, "F", and its related economic and water characteristic factors are summarized as follows·

Basic Equation: $$F = \frac{E \times O}{R \times T}$$

where·

F = The ratio of future to present industrial water needs

E = The employment factor; a ratio of future employees to employees in the base year

O = The output per employee factor; a ratio of future to base outputs per employee

R = The recirculation factor (See Table 12)

T = The technological improvement factor (See Table 12)

The numerator of this equation is primarily based on economic parameters of a geographic area, while the denominator accounts for technological improvements in industrial water using processes.

The ratios of E and O were determined for each major water using industry by use of projected values contained in Appendix B, NAR Study. These NAR values reflect estimated industrial growth trends and consist of two major parts an historical and current picture of the economy for each OBE area; and a projection of these economic pictures to the benchmark years of 1980, 2000, and 2020. (The areal units of the NAR Study, however, are considerably larger than the UMA's.)

The parameters of R and T were determined on a straight line relationship for each major water using industry based on a value of 1.0 for 1970 and values derived from information provided by the Corps of Engineers for the year 2020. These values for any given year were considered uniform for the entire NEWS study area and are shown in Table 12.

TABLE 12

RECIRCULATION (R) AND TECHNOLOGICAL

IMPROVEMENT (T) FACTORS

Industrial Group	1980 R	1980 T	2000 R	2000 T	2020 R	2020 T
Food	1.2	1.1	1.5	1.2	1.9	1.3
Textiles	1.2	1.1	1.7	1.2	2.1	1.3
Chemicals	1.5	1.2	2.5	1.4	3.5	1.7
Paper	1.2	1.1	1.7	1.2	2.1	1.4
Petroleum	1.5	1.2	2.5	1.4	3.5	1.7
Primary Metals	1.2	1.1	1.7	1.2	2.1	1.3

The use of the NEWS methodology, which reflects technological improvements in industrial water use, and the use of NAR estimates of future economic development in each industry provide the "F" factor for projecting water use requirements. Table 13 shows the "F" factors used in this study.

Determination of Present Water Use

To apply these "F" factors in projecting total industrial water demands, some measure of present industrial activity related to present water use was necessary. Present industrial outputs were determined using the same method and two sources. The first source was based on values of industrial outputs as given in Appendix B, NAR Study and the other based on actual values of output (Value Added (V.A.) Dollars) as given in the "1963 Census of Manufacturing" and "1967 Census of Manufacturing" published by the U.S. Bureau of the Census. Use of NAR data yields values only for each of six major water using industries (food, textiles, etc.) with respect to a given OBE area. (See Figure 3.) The Census data, on the other hand, accounts for all the major industries present in an area. The latter also accounts for the minor water using industries, which in some UMA's are a significant part of the total industrial water use. When considering a small area, however, census regulations, prohibiting disclosure of confidential company data, limit the completeness of reported information. Therefore, for this study, estimates of present water use were averaged using the results of both of these sources.

TABLE 13

SUMMARY
"F" FACTORS FOR INDUSTRIAL WATER PROJECTIONS

INDUSTRIAL CATEGORICAL GROUP

1980

(OBE) Area	Food	Textile	Chemical	Paper	Petrol.	Primary Metals	Other
Bangor	1 07	1 25	94	1 12	-	-	
Portland-Lewiston	1 10	98	1 16	97	-	1 48	1 2
Manchester-Nashua	1 08	98	1 25	97	-	1 06	"
Burlington	1 03	92	1 15	1 13	-	1 04	"
Pittsfield	1 03	95	95	90	-	1 07	"
New London-Hartford	1 03	88	1 02	1 11	1 02	86	"
Albany-Schenectady-Troy	1 03	95	95	90	1.02 (1)	1 07	"
Utica-Rome-Syracuse	98	90	1 00	95	1 02 (1)	80	"
Rochester	98	1 01	98	1 09	-	98	"
Binghamton-Elmira	1 03	96	99	88	-	87	"
Scranton-Wilkes-Hazel	1 09	93	1 21	96	-	86	"
Altoona-Williamsport	1 12	1 01	1 23	96	-	1 08	"
Reading-Allentown-Easton	1 00	87	1 08	1 04	1 02 (1)	98	"
Philadelphia	1 04	85	1 10	1 11	1 02	1 02	"
Trenton-Atlantic City	1 04	85	1 10	1 11	1 02	1 02	"
Wilmington	1 04	85	1 10	1 11	1 02	1 02	"
Richmond	1 06	1 11	1 02	1 21	1 02 (1)	1 08	"
Lynchburg	1 17	1 16	96	92	-	1 22	"
Newport News-Norfolk Portsmouth	1 08	-	1 06	1 21	1 06	96	"

2000

(OBE) Area	Food	Textile	Chemical	Paper	Petrol.	Primary Metals	Other
Bangor	1 41	1 56	1 39	1 47	-	-	1 5
Portland-Lewiston	1 48	1 00	2 20	1 04	-	1 82	"
Manchester-Nashua	1 44	1 04	2 39	1 01	-	1 32	"
Burlington	1 22	96	2 50	1 27	-	1 34	"
Pittsfield	1 28	90	1 60	78	-	1 21	"
New London-Hartford	1 30	76	1 89	1 36	1 27	67	"
Albany-Schenectady-Troy	1 28	90	1 61	78	1 40 (1)	1 21	"
Utica-Rome-Syracuse	1. 17	87	1 65	1 00	1 40 (1)	70	"
Rochester	1 10	1 14	1 67	1 34	-	1 02	"
Binghamton-Elmira	1 29	85	1 67	70	-	73	"
Scranton-Wilkes-Hazel	1 46	81	2 46	88	-	72	"
Altoona-Williamsport	1 53	1 03	2 52	94	-	1 28	"
Reading-Allentown-Easton	1 15	80	2 06	1 15	1 45 (1)	99	"
Philadelphia	1 26	79	2 12	1 38	1 45	1 11	"
Trenton-Atlantic City	1 26	79	2 12	1 38	1 45	1 11	"
Wilmington	1 26	79	2 12	1 38	1 45	1 11	"
Richmond	1 34	1 42	1 81	1 69	1 45 (1)	1 27	"
Lynchburg	1 69	1 52	1 66	93	-	1 74	"
Newport News-Norfolk Portsmouth	1 42	-	1 89	1 86	1 52	1 21	"

2020

(OBE) Area	Food	Textile	Chemical	Paper	Petrol.	Primary Metals	Other
Bangor	1 87	2 32	2 06	2 00	-	-	
Portland-Lewiston	1 94	1,14	3 89	1 21	-	2 46	
Manchester-Nashua	2 00	1 27	3 85	1 07	-	1 88	
Burlington	1 44	1 09	3 86	1 52	-	1 70	
Pittsfield	1 61	97	2 35	83	-	1 64	
New London-Hartford	1 71	82	2 95	1 80	2 02	75	
Albany-Schenectady-Troy	1 61	97	2 35	83	2 05 (1)	1 64	
Utica-Rome-Syracuse	1 50	1 03	2 36	1 12	2 05 (1)	88	
Rochester	1 30	1 57	2 38	1 71	-	1 26	
Binghamton-Elmira	1 64	1 04	2 39	62	-	79	
Scranton-Wilkes-Hazel	1 92	96	3 71	85	-	77	
Altoona-Williamsport	2 01	1 25	4 25	1 01	-	1 75	
Reading-Allentown-Easton	1 40	,85	3 21	1 39	2 06 (1)	1 21	
Philadelphia	1 58	84	3 27	1 81	2 06	1 44	
Trenton-Atlantic City	1 58	84	3 27	1 81	2 06	1 44	
Wilmington	1 58	84	3 27	1 81	2 06	1 44	
Richmond	1 70	1 96	2 75	2 41	2 06 (1)	1 67	
Lynchburg	2 33	2 18	2 50	1 09	-	2 69	
Newport News-Norfolk Portsmouth	1 89	2 72	2 72	2 83	2 13	1 46	

(1) Since only output values were listed, the above values were interpolated

1 Bangor, Me.
2 Portland, Me.
3 Burlington, Vt.
4 Boston, Mass.
5 Springfield-Hartford, Conn.
6 Albany, N. Y.
7 Plattsburgh, N. Y.
8 Syracuse-Utica, N. Y.
9 Rochester, N. Y.
10 Buffalo, N. Y.
11 Erie, Pa.
12 Williamsport, Pa.
13 Binghamton, N. Y.
14 New York, N. Y.
15 Scranton-Wilkes-Barre, Pa.
16 Philadelphia-Trenton-Wilmington
17 Harrisburg-York-Lancaster, Pa.
18 Washington-Baltimore
19 Staunton-Winchester, Va.
20 Roanoke-Lynchburg, Va.
21 Richmond, Va.
22 Norfolk, Va.

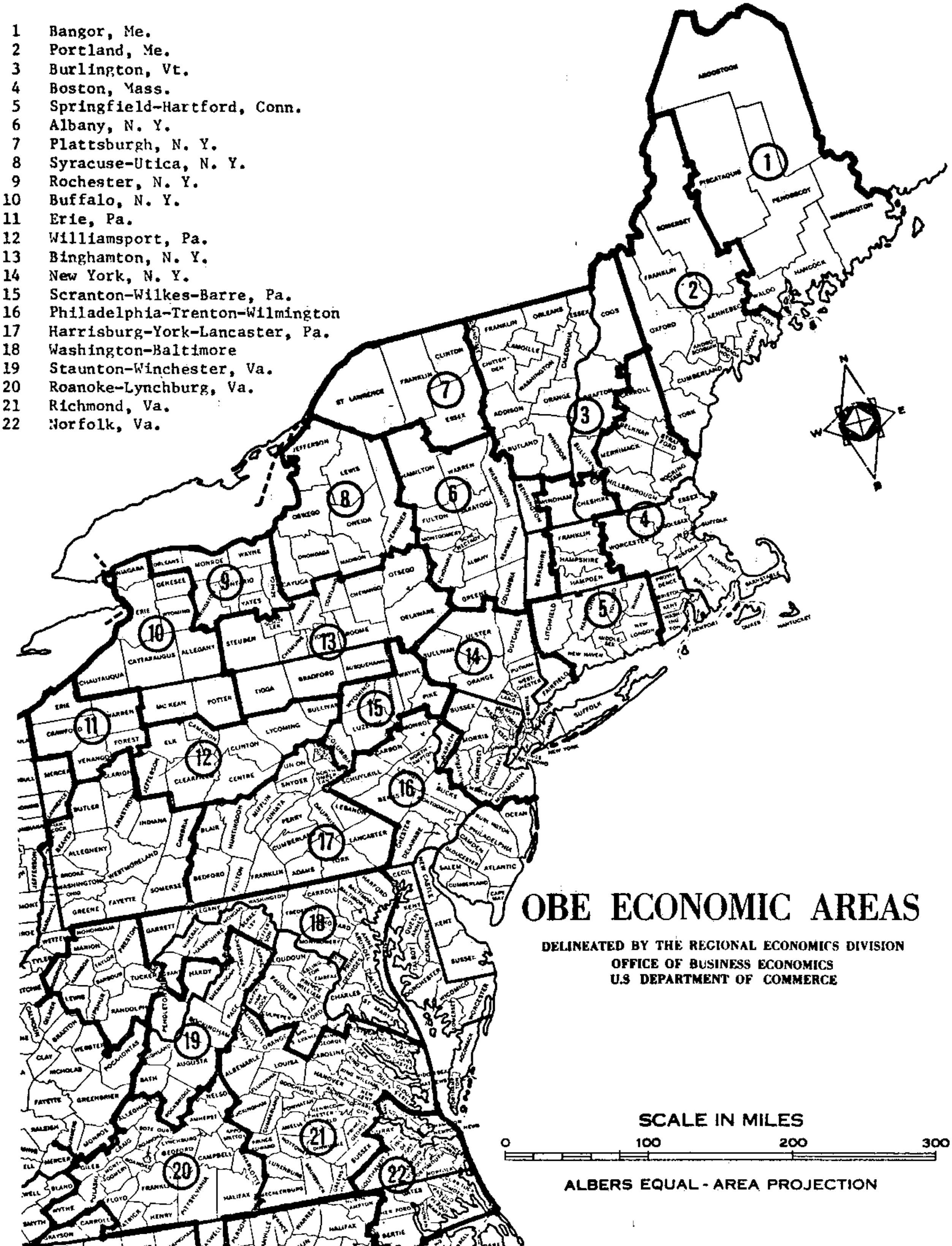


FIGURE 3

The method uses as a measure of industrial activity the "dollar of value added by the manufacturer" which as stated by the Census, "... is considered to be the best measure now available for comparing the relative economic importance among industries and geographic areas."

Using the NAR figures of employment and output, $\frac{\text{V.A. Dollars}}{\text{Employee}}$ yields a measure of manufacturing for a certain industry (food, textiles, etc.) within a given OBE area. These measures of manufacturing were then disaggregated to the county and/or SMSA which contains the UMA. At this level (county or SMSA), limited available actual census data denies the possibility of gaining an exact measure of output. These census data, however, yield values of output more closely related to the UMA for comparison with the values disaggregated from the larger OBE area upon which the "F" factors were based. Similar disaggregation was required in the original preparation of the NAR report where it was necessary to break areas into parts which could be reassembled into the hydrologic planning areas. This was done by a percent-share method. Similarly, a percent-share method was also used in this study to determine county and SMSA industrial activity.

To convert these outputs (V.A. Dollars) to water requirements, some measure of water use was needed. Values of water use are categorically listed according to the overall U.S., state and water use region in the U.S. Census of Manufacturing, 1963". Mid 1960's water use in billion gallons per V.A. Dollars were obtained from this listing and then related to the comparable industrial outputs, yielding base year water use for projections to the target years by applying the dimensionless "F" factors. Adjustments were made either upward or downward in a few UMA's of the projections of total industrial water demands where available information supported such changes. The total industrial water demands for each UMA are given in Table 6, p. 15.

In summary, the procedures outlined for determination of future industrial water demands basically evolve from the "dollar of value added by manufacturers" which presently is considered the most indicative measure of industrial activity for any geographic area. The areal limits of the UMA were determined from population and land use projections, which are also indicators of industrial activity. However, when considering an area such as the UMA, either population or land use per se could in fact "miss" an industrial area such as peripheral industrial parks. For each UMA, population and the value added dollar are interrelated, yet when considering total water needs, they can also serve as independent parameters upon which to base different water demands.

DERIVING M & I WATER DEMANDS

The two methodologies described in the foregoing sections provide means of projecting water demands independently of each other. However, the results of each contain an overlap, namely, the projection of publicly supplied industrial water. To reach the objectives of this study, it is essential that one must determine the future demands for domestic and publicly supplied industrial water, commonly referred to as M & I (municipal and industrial) water demands. Because the water resources available in each area differ, the amount of M & I water required becomes the key to determining the amount of source development and pumping, treatment, and transmission capacity required.

In this study, one of the following three assumptions was applied in each UMA to determine the M & I water demands:

- If the yield of sources of fresh water supply available to industry for the future is practically unlimited, and there is no additional information to the contrary, the water demand as projected using the NARRE method was used without modification, as the M & I water demand.

- If the yield of sources of fresh water available to industry for the future is very limited, and there is no additional information to the contrary, the publicly supplied industrial water was determined by assuming that all new demands over present self-supplied industrial capacity would be obtained from public supply.

- If the yield of sources of fresh water lies between the above extremes, and there is no additional information to the contrary, a value for the publicly supplied industrial water was selected that seemed reasonable.

Nearly all planning documents reflect the present amount of publicly supplied industrial water. The difference between the publicly supplied industrial and total publicly supplied water is the domestic supply. Likewise, the difference between publicly supplied industrial and total industrial water demand is the self-supplied component.

In evaluating the publicly supplied industrial water, such additional information as could be found in the literature or as had been received through other communications was considered in arriving at the reasonableness of these projected demands.

Multiplication of the ratio of publicly supplied industrial water to the total publicly supplied water use in the base year by the projected water demand, obtained from the NAR Regression Equation, in each benchmark year yields a product - assumed to be the future publicly supplied industrial water in the same proportions as the base year. This product also reflects the historical trend up to the base year. The difference between the total demand obtained from the NAR Regression Equation and this future publicly supplied industrial water is assumed to be the domestic component. This procedure was used to obtain the domestic component of M & I water in all UMA's.

Using a similar ratio of publicly supplied industrial water to the total industrial water in the base year and multiplying by the projected total industrial water demand, obtained from the NEWS methodology, in each benchmark year yields a product. This product might also be assumed to be the publicly supplied industrial water and if it is subtracted from the total industrial water demand, difference would represent the self supplied component.

Both of these ratios and products were used in seeking reasonable results for publicly supplied industrial water demands for UMA's for which the third assumption was found applicable.

Using the following fictitious information and applying the ratios discussed above, the results are shown in Figure 4 to illustrate the three assumptions to derive the M & I water demands.

Water Item	Base Year	Assumption 1 2020	Assumption 2 2020	Assumption 3 2020
Domestic	80	120	120	120
Publicly Supplied Industrial	20	30	70	50
Municipal & Industrial	100	150	190	170
Publicly Supplied Industrial	20	30	70	50
Self-Supplied Industrial	100	140	100	120
Total Industrial	120	170	170	170

ILLUSTRATIVE M&I WATER DEMANDS

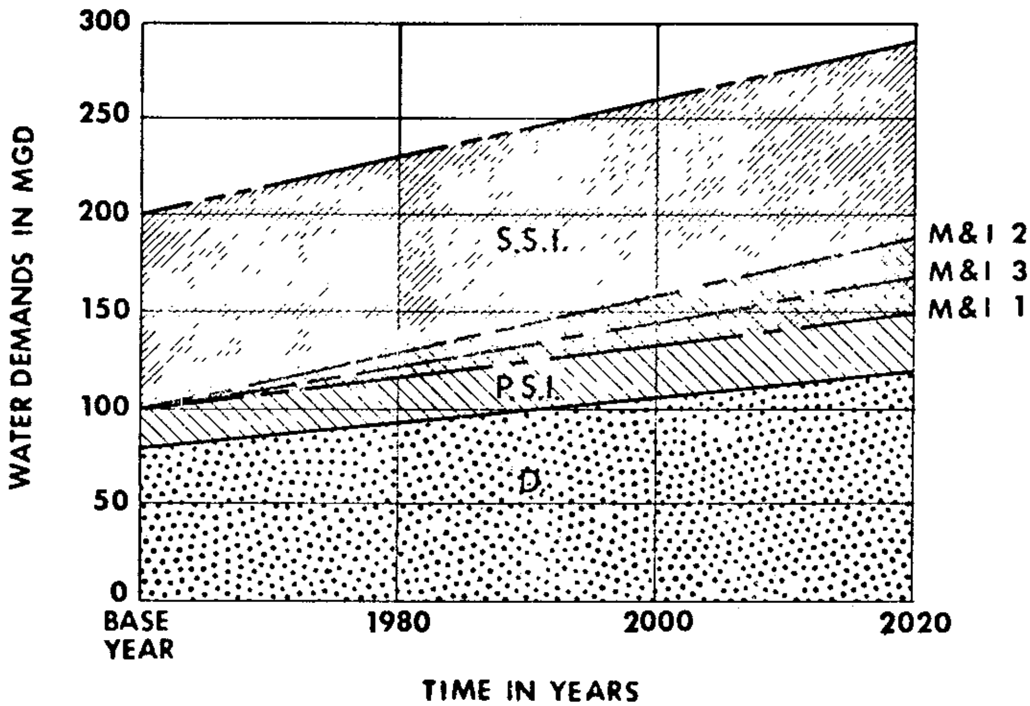


FIGURE 4

SUPPLY CAPABILITIES

Capabilities of water supply for each UMA were analyzed to determine how well present development of resources could meet future demands. The procedure of analysis for this preliminary study was simplified by assuming that all resources and facilities are available collectively to meet the demands of the future. The results reveal the base minimum development required. If it were possible to establish a single management agency in each UMA and place all of the resources and facilities -- sources, reservoirs, wells, pumping and treatment plants, and transmission mains -- under its control, these requirements would then be truly representative. Some exceptions might require larger developments such as topographic and geographic barriers, installed facilities that would defy hydraulic modification, and insufficient, unavailable, or unsuitable quality sources. Realistically, however, few UMA's have a single management at present. In fact, proliferation of water utilities in most of the UMA's is a strong argument against the use of this simplification. It has been used, nevertheless, to illustrate the need to rectify or at least regress the trends that lead to the situation faced in the 1960's drought.

Depending upon its size, present capabilities might include all developed utilities in others only the major utilities (those supplying at least 1 mgd except in the Philadelphia-Trenton-Wilmington UMA where 5 mgd was used) were added together. However, each UMA was considered separately and the results are presented in Volume II.

Sources of water supply include surface and ground water. The safe yield of each source presently developed was sought or estimated wherever possible and presented both in tabular form and on a graphic in the appropriate chapter in Volume II. Likewise, the treatment plant and transmission capacities were sought and tabulated.

Based on the limiting factor of source, treatment, or transmission, the present system capacity was determined. Because of the relative ease of increasing the capacity of treatment plants and pumping and transmission capacity, recent additions may have already increased the stated capacities. However, as of the date of preparation of this study, it represents the best relative capability to compare against the water supply demands.

THE SHORTAGE INDEX METHODOLOGY

Numerous methodologies have been proposed, developed, and implemented during the last several years for generating synthetic hydrologic data from available historic data. With these techniques, it has been possible either to reconstitute from the actual flows, recorded at a gaging station, the natural streamflows which would have been observed in the absence of upstream regulation; or to extend the flow records of streams with a relatively short duration, so that the number of years of record at all stations within a river basin or sub-basin would be the same.

Because these methodologies and techniques are covered quite extensively in literature pertaining to the field of hydrology, no detailed description of these methods will be presented in this section. These techniques, however, are the foundation upon which the Shortage Index and its applications are based. The Shortage Index serves as a parameter for comparing and/or establishing the yield-storage relationship for major reservoirs, either in existence or proposed.

Appendix C, Climate, Meteorology and Hydrology, NAR Study, describes the Shortage Index methodology and presents a series of five tables, one for each of the subregions of the Northeastern United States. The tables were used to calculate or confirm storage requirements and availability for the UMA's, whenever applicable. No finite determination of the yield/storage relationship was made; rather, the shortage index was utilized as one method of evaluating and comparing data given in planning documents. It was also used to estimate the yield/storage of a specific site where no data were available. By comparing known values of one stream (drainage area, average flow, etc.), the flows at an ungaged site with similar characteristics (size, topography, geographic proximity, etc.), can be estimated with confidence by using the Shortage Index Methodology.

OTHER METHODOLOGIES

Although the Shortage Index Methodology was found useful, in many instances more standard methods were used to confirm or calculate storage requirements. These methods included the use of the New England Water Works Association curves, Rippl diagrams (mass curves), and the Hazen storage methodology as found in Abbetts American Civil Engineering Practice, Volume II. In general, these standard methods were used when the drainage area under consideration was less than about 100 square miles.

BASIS OF COST ESTIMATES

The majority of the many plans reviewed contain a wide range of projects with applicable cost estimates and data. This section was prepared, and used where it seemed appropriate, to explain the basis of the methodology for those order of magnitude costs for construction not included as part of the plans mentioned above. It is to be stressed that in keeping with the intent of this report, all costs are preliminary and should not be construed as the results of detailed analyses. No attempt was made to determine annual costs for any alternative, which might have permitted comparing alternative projects on the basis of cost. Such costs may well be considered, however, as an integral part of any continued (perhaps feasibility scope level) investigation.

The construction cost of a project was obtained after separating the project into its major components: storage reservoir, pumping, transmission, and treatment; and costing these components by using the generalized table and cost curves presented in this section. In some cases, only the component construction cost is cited.

COST OF RESERVOIRS

The cost of reservoirs, in dollars per acre-foot of storage, was updated to reflect 1970 costs from the original 1960 estimates prepared by the U.S. Army Corps of Engineers and recorded in Todd's The Water Encyclopedia. Table 14 lists the physiographic regions within the NEWS Study Area for reservoir costing purposes and shows the reservoir cost estimates for each physiographic region by size class. (See Figure 5 for physiographic regions; UMA Chapter Number refers to Volume II, Area Reports.)

TABLE 14

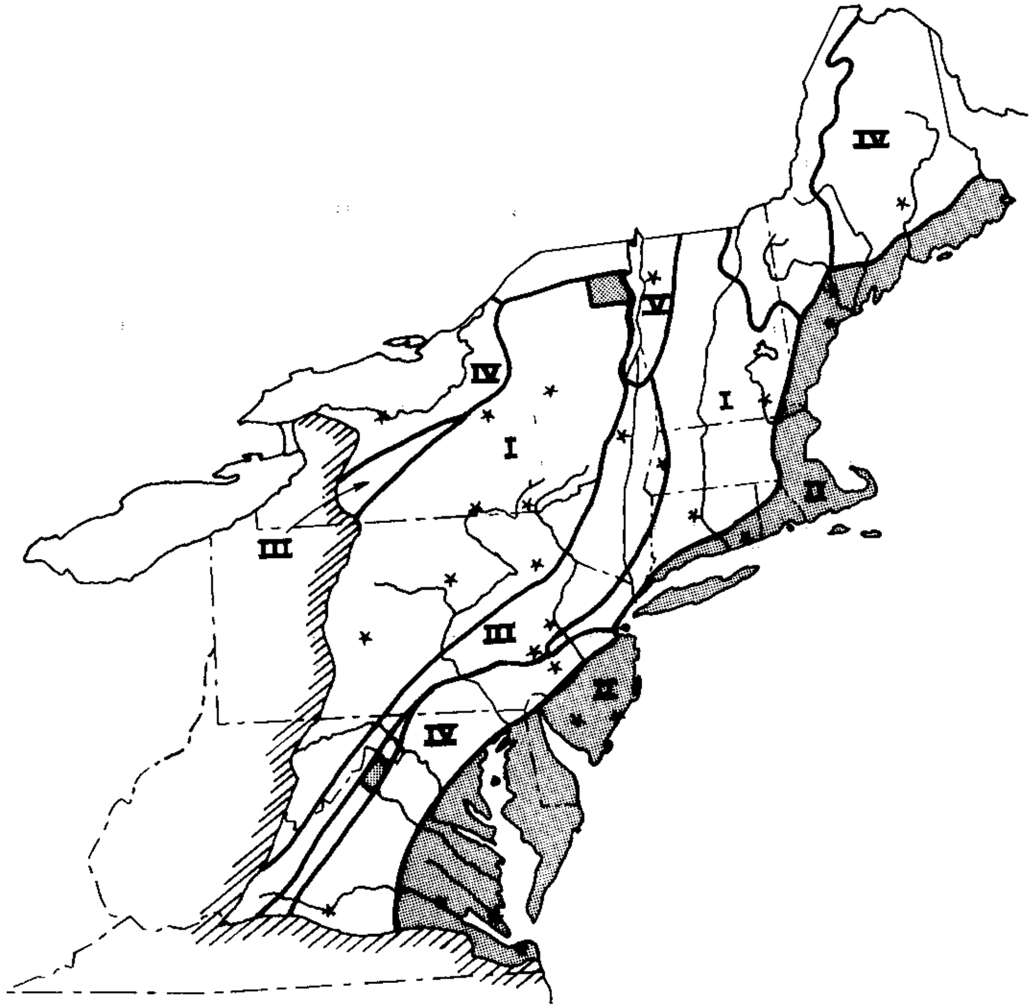
COST OF RESERVOIRS WITHIN PHYSIOGRAPHIC AREAS THROUGHOUT THE NEWS STUDY AREA

Values Are In Dollars Of Reservoir Storage Per Acre-Foot

Physio-graphic Region	UMA's Included: Chapter No.	UMA's Included: Name	10	30	50	80	150	300	700	1,500	3,000	7,000	30,000
	8	New London-Groton-Norwich											
	9	Hartford											
	11	Utica-Rome											
I	12	Syracuse	$367	$293	$266	$242	$211	$164	$156	$136	$118	$101	$74
	14	Binghamton											
	15	Elmira											
	16	Scranton-Wilkes-Barre											
	17	Williamsport											
	18	Altoona											
	3	Lewiston-Auburn*											
II	4	Portland*	291	219	192	170	143	119	95	77	64	51	33
	5	Manchester-Nashua											
	7	Pittsfield											
III	10	Albany-Schenectady-Troy	266	195	165	147	120	101	79	63	52	39	26
	19	Allentown-Bethlehem-Easton											
	20	Reading											
	2	Bangor											
	13	Rochester											
	21	Philadelphia-Trenton-Wilmington											
IV	22	Atlantic City*	219	157	133	133	91	73	55	44	33	26	18
	23	Vineland*											
	24	Lynchburg											
	25	Richmond											
	26	Newport News											
	27	Norfolk											
V	6	Burlington	173	119	101	84	69	55	40	33	27	18	15

*Areas in which major storage reservoirs cannot be constructed or are not likely to be needed.

Physiographic Regions of the NEWS Study Area



Areas in which major storage reservoirs cannot be constructed or are not likely to be needed

Source: Corps of Engineers, U S Army, 1960

FIGURE 5

COST OF WATER TREATMENT PLANTS

Conventional treatment facilities for surface water supplies are assumed to include coagulation and settling basins, dual media filters, chlorination equipment, and all related chemical feed equipment. Figure 6 shows the cost in millions of dollars versus the size of the treatment plant in millions of gallons per day.

PUMPING STATION COSTS

Pumping station cost estimates include the stations along the major transmission mains and at the treatment plant. Figure 7 shows graphically the cost per installed horsepower (dollars) against the required horsepower.

PIPELINE COSTS

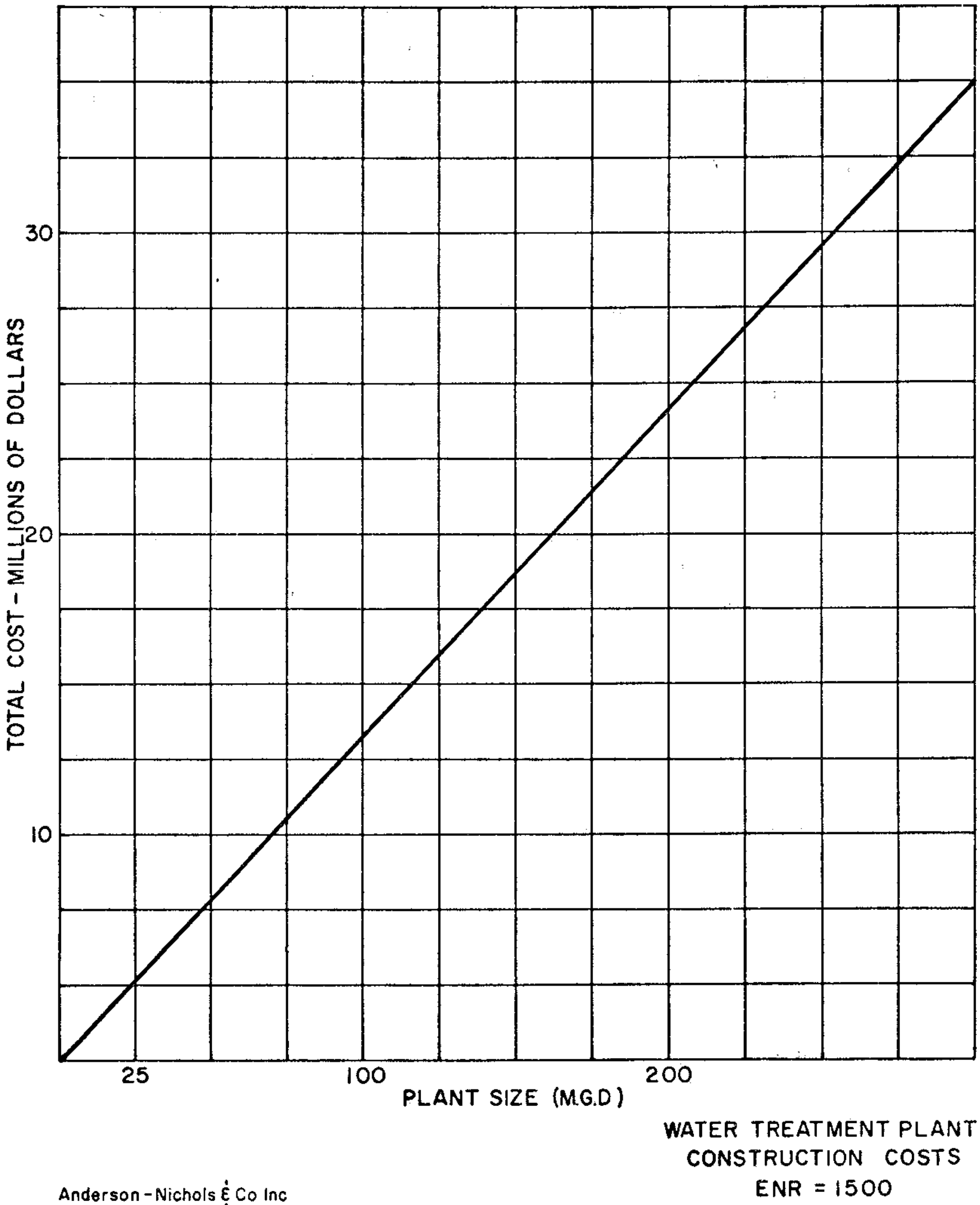
Cost per linear mile for pipes ranging in size from 24" to 120" are shown graphically on Figure 8 for prestressed concrete cylindrical pipe for pressure ranges of 50 p. s. i. to 300 p. s. i. Generally, 100 p. s. i. or 200 p. s. i. pipe was used for cost estimating.

TUNNELING COSTS

Estimated costs for tunnels were based on tunnel construction using a dry heading with rib supports and reinforced-concrete liner. Costs per linear mile for tunnels ranging in diameter from 8 to 20 feet are shown on Figure 9 .

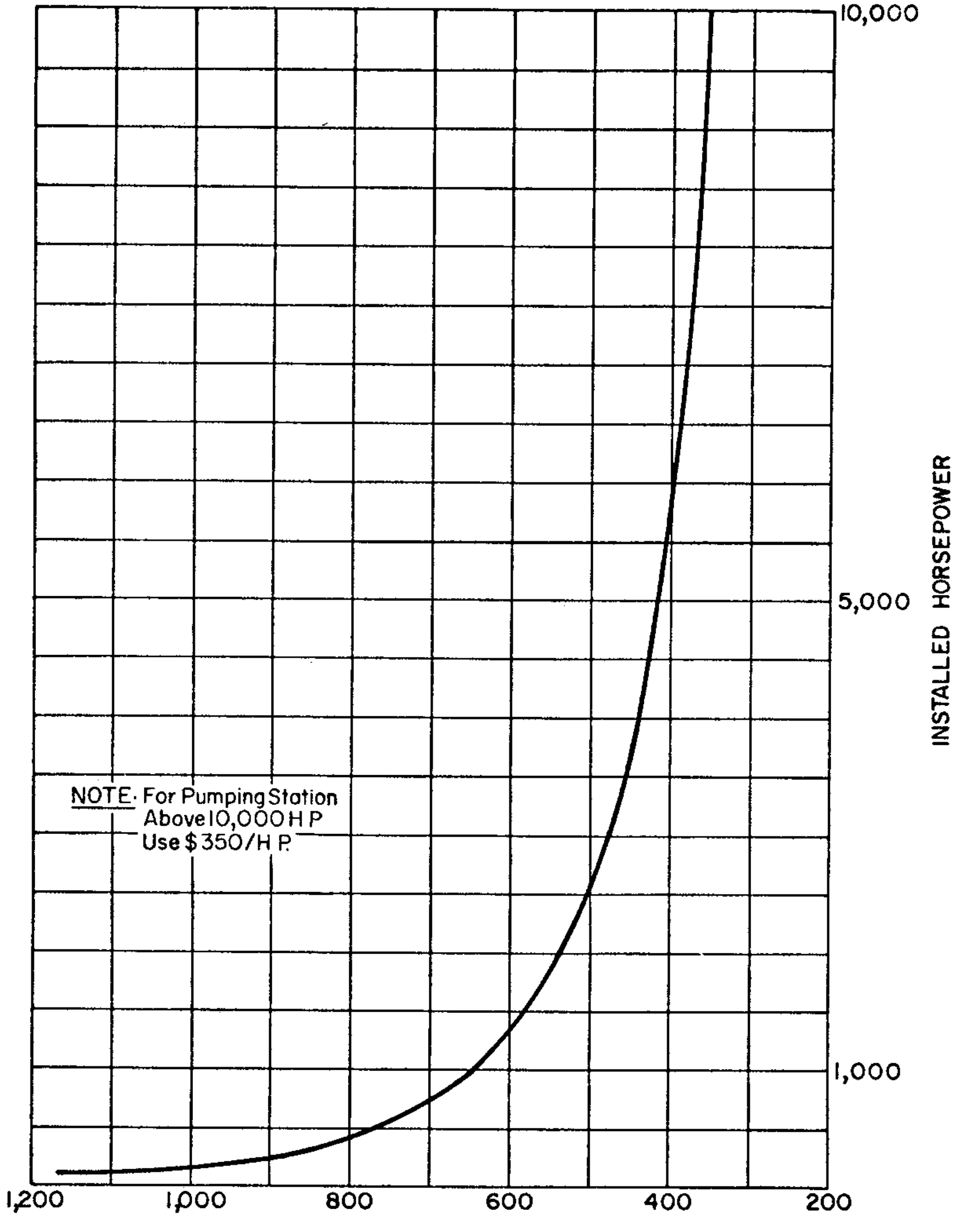
CONSTRUCTION COST INDEX

The Construction Cost Index for the 20 U.S. Cities Average of approximately 1500, as published by Engineering News Record, in 1970,was used as the base for all construction costs that were estimated in this report. The curves presented do not include an allowance for engineering and contingencies which might range from 25 to 35 percent of the estimated project costs.



30
20
10
TOTAL COST - MILLIONS OF DOLLARS
25
100
200
PLANT SIZE (M.G.D)
WATER TREATMENT PLANT
CONSTRUCTION COSTS
ENR = 1500
Anderson - Nichols & Co Inc

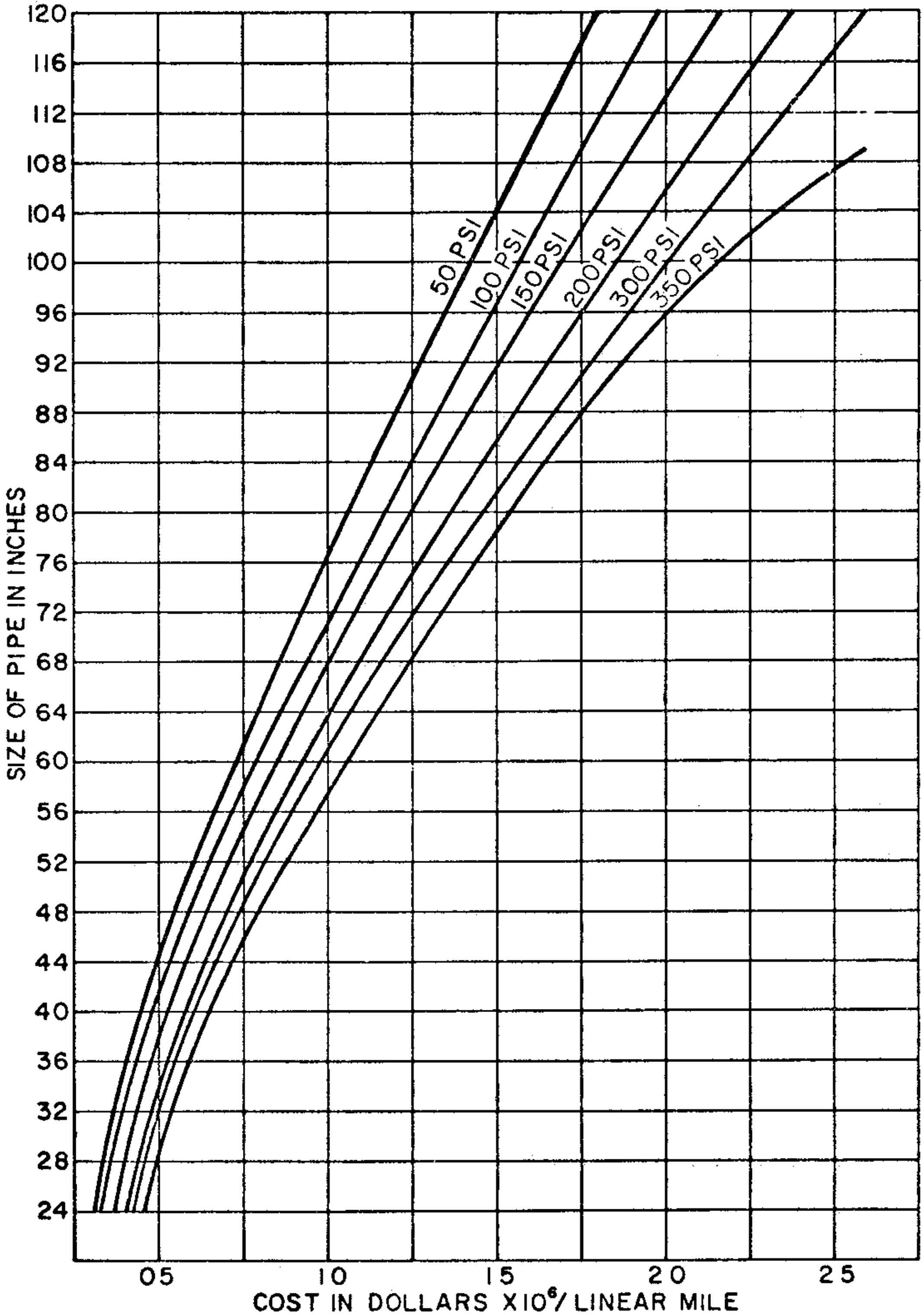
FIGURE 6



PUMPING STATION
CONSTRUCTION COST
ENR = 1500

Anderson-Nichols & Co Inc

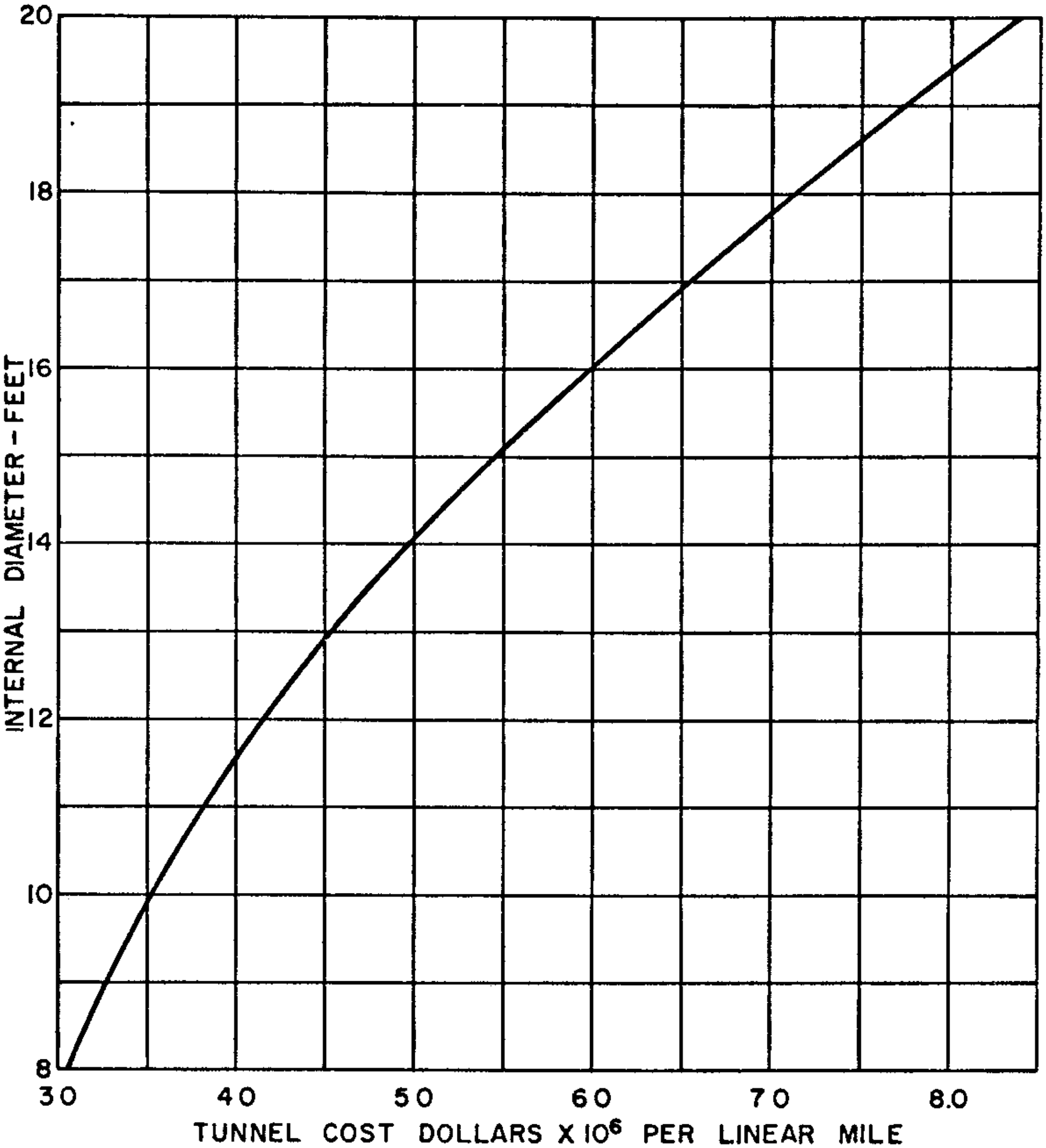
FIGURE 7



Anderson - Nichols & Co Inc

COST OF TRANSMISSION MAINS
ENR = 1500

FIGURE 8



Anderson-Nichols & Co Inc

COST OF TUNNELS
ENR = 1500

FIGURE 9

CHAPTER 5. ALTERNATIVE TECHNOLOGIES

WASTEWATER RECLAMATION AND REUSE

During the last several years there have been many discussions, amendments, bills, laws, programs and studies focused on the problems confronting the environment, and on what man can and must do to maximize the utilization of his resources. One resource that has received a great deal of attention is water -- especially its reclamation and reuse.

Water reclamation is the processing of wastewater for use in purposes ordinarily requiring water that is substantially free of pollutants. Water reuse is the utilization of reclaimed water for a variety of applications in agriculture, industry, and municipal water supply.

The public's esthetic barriers against and misconceptions of reclamation and reuse have delayed their acceptance. Gradually, however, anxieties are being dispelled as more information is made available. The public's hesitance to accept water disinfected by chlorination because of lack of knowledge is a situation analogous to that of wastewater reclamation and reuse.

Reuse as a practical method is already in operation. A survey of 155 cities showed that, during the minimum flow months of 1961, upstream municipal wastewater varied from a trace to as much as 18 percent. The upper limits are probably well above this by now. Furthermore, despite aesthetic rejection of water reuse for potable purposes, the public accepts without question the reuse of water in swimming pools.

The final answer is inevitable. There simply is not enough pristine water in this nation, even if the total could be distributed, to meet the requirements of drinking water. Practically all potable water has, at one time or another, been tainted by pollution.

Municipal wastewaters can be renovated at reasonable prices. As water-pollution laws become more stringent, requiring a greater degree of wastewater purification, the incremental cost of renovated wastewater as a source of water becomes less. Even where potable supply is the goal, investigations based on existing processes and equipment indicate a cost of 40 to 50 cents per 1,000 gallons (taking total cost less primary and secondary sewage-treatment costs).

Water reuse may be effected by any one or more of four basis cycles· hydrologic, natural, indirect, and direct. Definitions of each of these cycles follow.

The hydrologic cycle may be defined as the unending cycle, whereby water is precipitated from the atmosphere, evaporated from the surface or runs off the earth as surface water. It then either evaporates from the oceans, lakes, and rivers into the atmosphere, or percolates into the ground, is used by vegetation from whence it transpires into the air or returns again as seepage to the stream or ocean and eventually evaporates.

The natural cycle may be defined as the self-purification of flowing water, and sequential use of water by communities located one below another in the direction of flow. The natural cycle has existed since the introduction of water carriage system for waste disposal. Many classic examples of the natural cycle of water reuse can be found in the great river systems of the world.

The indirect cycle may be defined as the return of water used one or more times (wastewater) to the hydrologic and natural water cycles for reuse. In the past, the indirect water reuse cycle could be characterized as planned use of wastewater that had been treated specifically for the purpose of returning it to the natural water reuse cycle. In the light of recent developments, however, this characterization must be expanded to include the use of wastewater that has been treated specifically for the purpose of returning it to the hydrologic cycle. An example of the latter indirect cycle of water reuse involves groundwater recharge by both surface spreading and direct injection of treated wastewater.

The direct cycle may be defined as the planned treatment of wastewater so that the treated wastewater may subsequently be used for specific purposes. The number of applications of direct reuse is quite large and involves six categories· agriculture and food production, industrial uses, swimming pools, natural recreation areas, space vehicles, and municipal water supply.

Any one or combination of these four cycles is or can be implemented through natural or through man-made processes. The man-made processes are categorized as conventional or advanced. Conventional treatment is patterned on natural processes and carried out in specially designed tanks and reactors. Advanced treatment processes have been developed to provide a higher degree of treatment by utilizing both chemical and physical aids in speeding up and achieving greater purification. Table 15 summarizes the classification of wastewater reclamation.

TABLE 15

CLASSIFICATION OF WASTEWATER RECLAMATION PROCESSES

Classification	Process	Substances Removed
Biological	Conventional secondary treatment (trickling filter and activated sludge)	Suspended solids, soluble organic matter, and bacteria.
	Anaerobic denitrification	Nitrate nitrogen
	Algae harvesting	Nitrate nitrogen and phosphorus
Chemical	Ammonia stripping	Ammonia nitrogen
	Ion exchange	Nitrates and phosphates
	Electrodialysis	Salts
	Chemical precipitation	Suspended solids and phosphates
Physical	Activated carbon absorption	Organic compounds
	Sedimentation	Suspended solids
	Filtration	Suspended solids
	Reverse osmosis	Salts
	Distillation	Salts
	Foam separation	Detergents
	Land application	All pollutants

No attempt has been made here to present more than a brief critique on wastewater reclamation and reuse. The discussion included in this chapter should be a reminder that such a practical opportunity exists. Application to any specific area depends upon the social and economic impacts evaluated with other opportunities available that will promote wise use of water resources.

DESALTING

This section includes a brief description of existing methods and applications of the practice of "desalting." Presently, more than 300 mgd of desalting capacity is installed world-wide. Plants are generally located in arid regions where conventional water sources are high cost or unavailable. Principal areas of use are in the Mid-East and Caribbean tourist islands. In the United States, desalting for municipal water supply has thus far been limited to smaller communities, relatively isolated from sources of conventional supply.

The largest municipal desalting plant in the Unites States is a 2.6 mgd distillation process in Key West, Florida. Largest in the world is a French-built, 30 mgd distillation plant, recently completed in Kuwait.

The Saline Act of 1952 directed that a program of research and development be undertaken to explore large-scale, low-cost methods of desalting as a "means of producing from sea water, or from other saline waters, water of a quality suitable for agriculture, industrial, municipal, and other beneficial consumptive uses." The Office of Saline Water in the Department of the Interior has been directing the R&D program meant to achieve the goals directed by Congress.

Selecting a Process

Today, several desalting processes are commercially available to desalt feedwaters with salt concentrations ranging from a few hundred parts per million (ppm) to that of sea water, approximately 35,000 ppm, and even higher. State-of-the-art processes are many and varied. However, for purposes of this discussion, process descriptions will be limited to those considered, so to speak, as "worth their salt."

Many factors associated with a particular desalting application must be considered during selection of a suitable desalting process or processes. Those factors worthy of consideration in choosing a method include:

- o Salt concentration and composition of the feedwater.
- o Temperature of the feedwater.
- o Desired product water quality.
- o Availability of heat and energy.
- o Dependability of the feedwater source.
- o Waste brine disposal.
- o Site location.
- o Environmental factors.

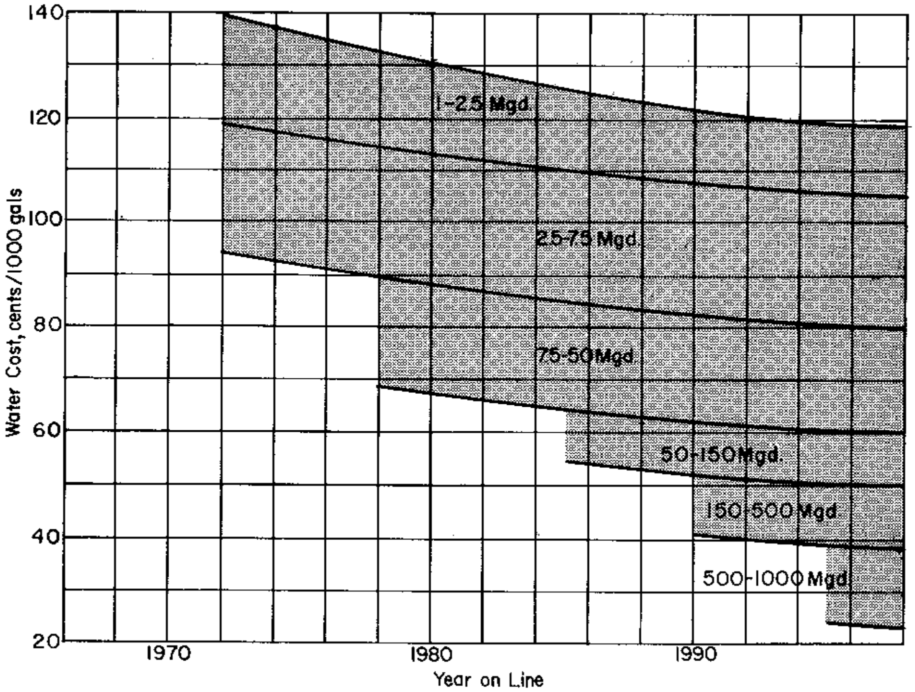
Current Methods. The most commonly used processes come under the general category of distillation, or heating feedwater and condensing freshwater. The specific variation currently used to produce up to 30 mgd from any one plant employs multi-stage flash chambers· feedwater enters progressively lower-pressured chambers with some water boiling instantly (flashing) at each stage of the operation. After condensation, the steam becomes the product water.

For requirements of 20,000 gpd to 1 mgd, vapor compression is a well-established method. To accomplish this process, steam is pressurized and heated with a mechanical compressor, then condensed on the outside of vertical tubes through which flows additional feedwater. This boils more brine, and produces desalted product water. Distillation is the preferred method when feedwater is seawater or the highly brackish water. Figure 10 graphically depicts current and projected construction costs for different sized distillation-type plants.

Another relatively widely used method involves membrane processes, including electrodialysis and reverse osmosis. Electrodialysis extracts dissolved salts from water, using membranes permeable to either positively or negatively charged ions. A "stack" of selected membranes, subjected to a direct current

SEAWATER DESALTING

COST FOR RANGE OF PLANT SIZE



ASSUMPTIONS

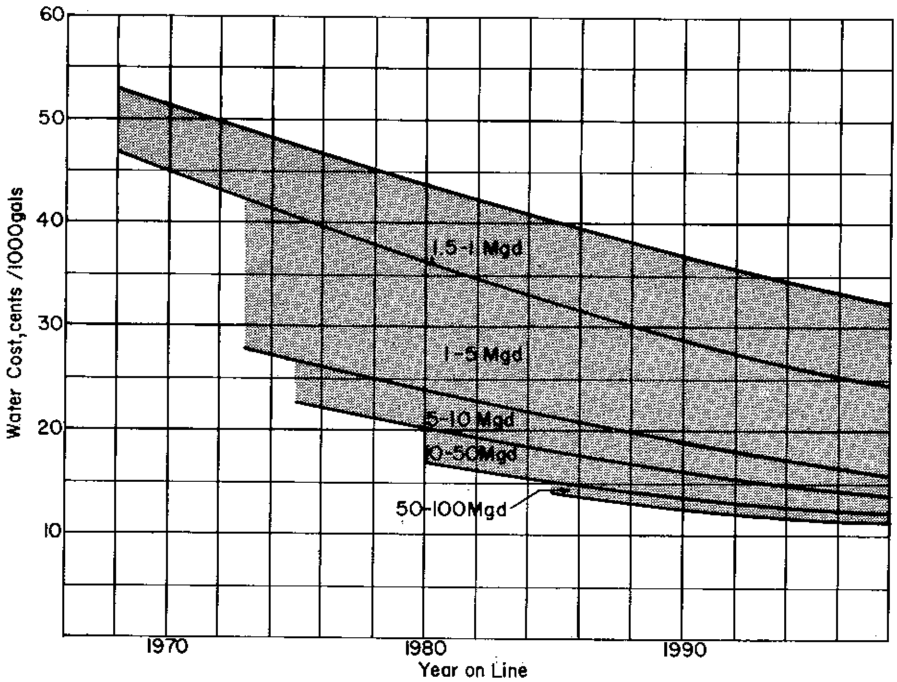
Distillation Technology
Including Anticipated Improvements
1st Quarter, 1972 Dollars
7 to 10 % Fixed Charges
30 Year Life Probable Energy Costs

SOURCE: Office of Saline Water
U S Department of the Interior

FIGURE 10

BRACKISH WATER DESALTING

COST FOR RANGE OF PLANT SIZE



ASSUMPTIONS
1st Quarter, 1972 Dollars
7 to 10% Fixed Charges,
30 Year Life Probable Energy Costs
Feedwater at 1500-2000 PPM
Product Water at 500 PPM
Membrane Technology
Including Anticipated Improvements

SOURCE: Office of Saline Water
U S Department of the Interior

FIGURE 11

potential and separated by spacers which allow flow between membranes, accomplishes purification as feedwater impurities are stopped by sequential membranes. Reverse osmosis involves a semi-permeable membrane which, when pressures of 200 to 600 pounds per square inch are applied to the feedwater, passes only freshwater. Membrane processes have so far proven most economical in converting feedwater with an initial dissolved solid concentration of less than 5,000 ppm. This process can accept feedwater with twice this concentration of solids, though not without a resulting loss of economy. Membrane plants can be readily located wherever electric power is available. Figure 11 shows current and projected construction costs for different sized membrane-type plants.

Two other processes should be mentioned, the vertical tube evaporation (VTE) and the ion exchange (IX) processes. Studies of the VTE process, used for desalting seawater, has indicated substantial savings in energy costs when combined with the multi-stage flash process. The IX process has great potential in cases where relatively small amounts of salts have to be removed and a high purity product is required. Both of these processes are described in detail in Chapter 4 of the Desalting Handbook for Planners, Bureau of Reclamation and Office of Saline Waters, U.S. Department of the Interior, First Edition - May 1972.

Plants Worldwide. As of January 1, 1970, 712 desalting plants capable of producing 25,000 gpd or more were either in operation or under construction throughout the world. Table 16 gives a breakdown of these plants by size. Interestingly, about 95 percent of these plants use some form of the distillation process.

TABLE 16

WORLDWIDE DESALTING DEVELOPMENT
ARRANGED BY SIZE OF PLANTS

Size Range (1000 gd)	No. Plants	Plant Capacity (mgd)
25 - 99	359	18.4
100 - 499	263	50.7
500 - 999	32	21.6
1,000 - 4,999	51	108.7
5,000 - or greater	7	45.2
Total	712	244.6

Applications

Some possible future applications of desalting in the Northeastern United States have been suggested by studies made for the Office of Saline Water.

Conjunctive Use. A desalting plant may be an attractive alternative to a "last added" reservoir in a system when increased firm yield is desired. The last added reservoir may represent a marginal investment in terms of dollars per unit yield of water, i.e., a heavy capital investment weighed against actual use during the period of hydrologic record on which its operation will be based. By contrast, a desalting plant represents a comparatively lower capital investment. Because it trades off capital cost for operating cost, the latter will be less significant in an economic analysis since the plant will be operated only during dry cycles. Also, since the plant will operate at a low plant factor, service life will increase.

The conjunctive use concept provides the water resource planner an interesting alternative in economic analysis. A desalting plant can be matched to the water demand curve, in modular fashion, much more closely than a dam and reservoir, since a dam is most economically constructed in relation to the site and stream hydrology rather than the demand curve. A desalting plant may be more desirable for financial considerations; i.e., since the desalting plant is less capital-intensive it may be more feasible for the water-supply agency to obtain financing or, in times of costly money, the desalting plant may be the more desirable investment.

Water Quality Enhancement. Desalting processes may prove to be especially valuable in maintaining low salinity of surface waters by reducing salt inflows from point sources. National effluent standards would have the effect of assessing users not merely for water withdrawn but for any degradation of water quality that might result from use - they would pay the cost of bringing effluent to a certain standard. Desalting processes might be among those selected for water treatment, especially for industrial effluents. For example, the reverse osmosis method, among others, may be used as a means of partial recovery of valuable industrial by-products as well as upgrading effluent quality. Ion exchange desalting is being field tested as a means of reducing the harmful effects of acid mine drainage waters.

Long term planning horizons will probably include management of wastewater for reuse. A desalting step following advanced wastewater treatment is indicated in many reuse cases, since conventional treatment processes are generally ineffective for removing dissolved inorganic salts.

Industrial Use. Purity specifications for industrial waters vary widely and depend entirely on the intended use. For cooling water in industrial condensers, highly saline water is often acceptable. On the other hand, requirements for pure process water are so stringent in many industries that plants often employ expensive and complex treatment techniques in addition to obtaining high quality, natural water.

The most common industrial water quality problems are turbidity and hardness, and both are amenable to relatively inexpensive treatment by conventional methods. However, when there are limitations on other constituents, a desalting process including selective ion-exchange processing of part or of all the water supply may be a desirable and economic solution.

Environmental Considerations

In considering placement for any type of desalting plant, environmental considerations are as important as any other factor. Remember - pure water is not the only product. A plant will produce extremely concentrated brine as an effluent, plus any waste products from the power source, such as soot, heat, smoke, toxic gasses, etc. So far as the brine effluent is concerned, plant placement is somewhat contraindicated where the outfall cannot mix with waters such as those to be found on the open coastline. Special design procedures would be required in the cases of estuaries or areas with restricted water interchange, as many life forms present might be adversely affected. Inland plant location causes even more problems, as brine disposal may violate pollution laws. Two methods of disposal have been studied: (1) evaporation to dryness, and (2) deep-well injection. Evaporation is expensive, though this is highly dependent on land costs, while injection-method costs are estimated at 25 to 70 cents per 1,000 gallons of brine. Other methods are currently under investigation.

Visual impact is another important parameter, as is consideration of land use. Factors amenable to the situation of a desalting plant, such as protection by sandy beaches, gently sloping terrain, proximity to population zones, etc., are the same sought by commercial development, and since a desalting plant is a heavy industrial-type structure, aesthetics may be cited as a valid argument in cases of less-than-ideal proposed placement.

Current Evaluation

Existing desalting operations are characterized by several constraining features. Among the most important are high total annual costs, relative to conventional water sources; the need for proof of large-scale plant operation; and the problem of brine disposal. In the future, as technology is further developed, several of the constraints will be lessened, and desalting may prove to be an attractive supplement to water supply in coastal and estuarine areas of the Northeast United States. Desalting processes may also serve future use as an aid in control of water quality.

CHAPTER 6. FINDINGS AND CONCLUSIONS

A generalized summary of regionalization of water supply in each of the 26 UMA's is given in Table 17, p. 69.

FINDINGS

Existing Systems

1. A total of 107 major systems and 377 minor systems were found in the 26 UMA's; more than 30 percent of these systems were in the Philadelphia-Trenton-Wilmington UMA.

2. Among these UMA's, 5 have complete, 16 have partial, and 5 have no interconnected systems.

3. Present capacity is limited by source for 11 of the UMA's; treatment only is the limiting factor for 3 UMA's; a combination of treatment and transmission-pumping is limiting in 8 UMA's; transmission is limiting in 2, and pumping in the remaining 2 UMAs.

4. The time phasing among the 26 UMA's shows that demand will first exceed capacity as follows:

1980	2000	2020	After 2020
5	15	5	1

5. Assuming that the accuracy of projected water demands might deviate by as much as 33 percent, at least 20 UMA's would still require additional capacity to meet 2020 demands.

6. Two of the five UMA's first showing deficits by 1980 must increase their capacity by about 25 percent to meet their 1980 demands; all five of these UMA's must at least double their capacities by 2020.

7. Expansion of source is critical for one UMA; in the other four UMA's showing deficits by 1980, treatment or treatment and transmission are considered critical.

8. Expansion of source and facilities to meet 2020 demands were found to be necessary among the 26 UMA's as follows·

Source	Treatment	Transmission-Pumping	Storage
19	19	26	13

Regionalization of Water Supply

1. The present extent of regionalization of water supply among the 26 UMA's reflects that 5 have total regionalization, 4 are in progress toward becoming totally regionalized, 1 has plans for total regionalization of its water supply, and the remaining 16 are partially regionalized. (Based on the definition of a regional water supply for this UMA Study.)

2. A single collective management for water supply exists in 4 UMA's, and essentially exists in a fifth; a collective management would be desirable in 10 other UMA's; and only for 2 UMA's does a single collective management appear undesirable.

CONCLUSIONS

1. Present facilities are generally adequate for the immediate future (say 1990) for all but five of the UMA's; and adequate for six UMA's, probably into the long-range future approaching 2020.

2. The five UMA's for which a deficit is indicated by 1980, must maintain aggressive action to assure that necessary supplies are available to meet the demands.

3. The relative order of priority of the five UMA's considering the seriousness of their problems, is

1. Norfolk
2. Altoona
3. Utica-Rome
4. Lynchburg
5. Williamsport

4. All of the UMA's are approaching their water supply problems along regional lines; the degrees of regionalization among them differ.

5. More extensive regional planning for the urban metropolitan areas, closely coordinated across institutional boundaries where they exist, is desirable for many of the UMA's.

6. Opportunities identified for meeting water supply demands through 2020 favor surface source development for 23 UMA's and will be required in 20 of them.

7. Groundwater opportunities are available for 12 UMA's; development is required for 5 and is desirable for 2 others.

8. Treatment and/or transmission facilities will be required in all of the UMA's to meet 2020 demands.

9. For the large number of utilities found in the 26 UMA's, many more planned, designed, and constructed interconnections are desirable.

10. Future technology is expected to provide additional opportunities for several of the UMA's in the form of desalting and reuse of stormwater or wastewater.

11. The provision of water supplies at the time and to the degree indicated in this study for each UMA should accommodate the steady and unencumbered growth of each UMA.

TABLE 17

SUMMARY OF U.M.A. REGIONALIZATION

	Utica-Rome, N.Y.	Norfolk, Va.	Altoona, Pa.	Lynchburg, Va.	Williamsport, Pa.	Manchester-Nashua, N.H.	Elmira, N.Y.	Allentown-Bethlehem-Easton, Pa. - N.J.	Philadelphia-Trenton-Wilmington, Pa. - N.J. - Md.	Albany-Schenectady-Troy, N.Y.	Richmond, Va.	New London-Groton-Norwich, Conn.	Newport News, Va.
PROJECTED DATES OF FIRST DEFICIT	**1980**	**1980**	**1980**	**1980**	**1980**	**2000**	**2000**	**2000**	**2000**	**2000**	**2000**	**2000**	**2000**
EXISTING SYSTEMS													
Major systems (number serving 1 or more mgd)	6	2	4	1	4	2	3	4	17	12	6	3	1
Minor systems (number serving less than 1 mgd)	20	--	1	--	5	6	2	13	133	16	--	37	--
Interconnected systems (status)	None	Partial	Partial	Complete	None	Partial	Partial	None	Partial	Partial	None	None	Complete
Ratio of 2020 deficit to present capacity	1.67	1.33	1.29	1.23	0.96	1.66	1.46	1.04	0.93	0.88	0.85	0.81	0.80
Limiting factor(s) of systems	Treatment	Source	Transmission Treatment	Treatment	Transmission Treatment	Source	Source	Source	Source	Transmission Treatment	Treatment	Source	Source
Expansions to meet future requirements:													
Source	Necessary	Critical	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Unnecessary	Necessary	Necessary
Treatment	Critical	Necessary	Critical	Critical	Critical	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Under Construction
Transmission - Pumping	Necessary	Necessary	Critical	Necessary	Critical	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Under Construction
Interconnections	Necessary	Necessary	Necessary	--	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Unnecessary	Necessary	--
Storage	Necessary	Possible	Necessary	Possible	Possible	Necessary	Necessary	Necessary	Necessary	Unnecessary	Unnecessary	Necessary	Necessary
REGIONALIZATION OF WATER SUPPLY													
Present extent of regionalization	Partial	Partial	Planned	Total	Partial	Partial	In Progress	Partial	Partial	Partial	Partial	Partial	Total
Collective Management	Desirable	Desirable	Desirable	Exists	Desirable	Desirable	Desirable	Desirable	Undesirable	Desirable	Undesirable	Desirable	Exists

	Syracuse, N.Y.	Burlington, Vt.	Rochester, N.Y.	Lewiston-Auburn, Me.	Bangor, Me.	Scranton-Wilkes-Barre, Pa.	Pittsfield, Mass.	Vineland, N.J.	Hartford, Conn.	Reading, Pa.	Portland, Me.	Atlantic City, N.J.	Binghamton, N.Y.
PROJECTED DATES OF FIRST DEFICIT	**2000**	**2000**	**2000**	**2000**	**2000**	**2000**	**2000**	**2020**	**2020**	**2020**	**2020**	**2020**	**After 2020**
EXISTING SYSTEMS													
Major systems (number serving 1 or more mgd)	5	2	2	2	2	3	1	3	9	3	1	6	3
Minor systems (number serving less than 1 mgd)	14	10	4	1	3	7	--	2	44	18	--	1	40
Interconnected systems (status)	Partial	Partial	Complete	Partial	Partial	Partial	Complete	Partial	Partial	Partial	Complete	Partial	Partial
Ratio of 2020 deficit to present capacity	0.71	0.66	0.63	0.58	0.43	0.39	0.33	0.35	0.29	0.27	0.09	0.06	0.00
Limiting factor(s) of systems	Transmission Treatment	Transmission Treatment	Transmission Treatment	Source	Source	Transmission Treatment	Source	Pumping	Transmission Treatment	Source	Transmission	Pumping	Transmission
Expansions to meet future requirements:													
Source	Necessary	Unnecessary	Unnecessary	Necessary	Necessary	Necessary	Necessary	Unnecessary	Necessary	Necessary	Unnecessary	Unnecessary	Unnecessary
Treatment	Necessary	Necessary	Necessary	Unnecessary	Unnecessary	Necessary	Unnecessary	Unnecessary	Necessary	Necessary	Unnecessary	Unnecessary	Unnecessary
Transmission - Pumping	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary	Necessary
Interconnections	Necessary	Necessary	--	Necessary	Necessary	Necessary	--	Unnecessary	Necessary	Necessary	--	Necessary	Necessary
Storage	Unnecessary	Unnecessary	Unnecessary	Necessary	Unnecessary	Necessary	Necessary	Unnecessary	Necessary	Necessary	Unnecessary	Unnecessary	Unnecessary
REGIONALIZATION OF WATER SUPPLY													
Present extent of regionalization	In Progress	Partial	Partial	Partial	In Progress	Total	Total	Partial	Partial	In Progress	Total	In Progress	Partial
Collective Management	Desirable	Desirable	Desirable	Desirable	Desirable	Exists	Exists	Desirable	Desirable	Desirable	Exists	Desirable	Desirable

SUMMARY OF U.M.A. REGIONALIZATION
TABLE 17

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GENERAL

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GLOSSARY

acre-foot -- A term used in measuring the volume of water, equal to the quantity required to cover 1 acre 1 foot in depth, or 43,560 cubic feet.

appurtenances -- Machinery, appliances, or auxiliary structures attached to the main structure, but not considered an integral part thereof, for the purpose of enabling it to function.

aquifer -- A porous water-bearing geological formation.

chlorination -- The application of chlorine to water, sewage, or industrial wastes, generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

disinfection -- The killing of the larger portion (but not necessarily all) of the harmful and objectionable microorganisms in, or on, a medium by means of chemicals, heat, ultraviolet light, etc.

facilities, water-supply -- The works, structures, equipment and processes required to supply and treat water for domestic, industrial, and fire use.

field, well -- A tract of land containing a number of wells.

gallery, infiltration -- A gallery of some magnitude, with openings in its sides and bottom, extending generally horizontally, into a water bearing formation, for the purpose of collecting water contained therein.

lake -- An inland body of water, fresh or salt of considerable size occupying a basin or hollow on the earth's surface, and which may or may not have a current or single direction of flow.

lake, glacial -- A lake occurring in the bottom of a valley which was formed by glacial action, or a body of fresh water on the land surface impounded by a dam of glacial ice.

precipitation -- (1) The total measurable supply of water of all forms of falling moisture, including dew, rain, mist, snow, hail, and sleet; usually expressed as depth of liquid water on a horizontal surface in a day, month, or year, and designated as daily, monthly, and annual precipitation. (2) The process by which atmospheric moisture in liquid or solid state is discharged onto a land or water surface.

precipitation, annual mean -- The average over a period of years of the annual amounts of precipitation.

reservoir -- A pond, lake, tank, basin, or other space, either natural in its origin, or created in whole or in part by the building or engineering structures, which is used for storage, regulation, and control of water.

resources, water -- The supply of water in a given area or watershed, usually interpreted in terms of availability of surface and/or underground water.

runoff -- (1) That portion of the earth's available water supply that is transmitted through natural surface channels. In the general sense it is defined as that portion of precipitation which is not absorbed by the deep strata, but finds its way into the streams after meeting the persistent demands of evapotranspiration including interception and other losses. It includes surface runoff received into the channels after rainfall, delayed runoff that enters the streams after passing through portions of the earth, and other delayed runoff that has been temporarily detained as snow cover or stored in natural lakes or swamps. Some writers define runoff to include both direct runoff and groundwater runoff. (2) Total quantity of runoff during a specified time. (3) The discharge of water in surface streams usually expressed in inches depth on the drainage area or as volume in such terms as cubic feet or acre-feet, (4) That part of the precipatation which runs off the surface of a drainage area.

runoff, annual, mean -- The average over a period of years of the annual amount of runoff discharged by a stream.

shortage index -- The term "shortage index" pertains to criteria useful in planning water resource development and, in fact, has been selected as a parameter for the yield-storage relationships. The shortage index is described as equal to the sum of the squares of the annual shortages over a 100-year period, where each shortage is expressed as a ratio to the annual requirement. It follows that the numerical value of the index varies in direct proportion to the number of shortages and the square of the shortage quantities. Thus, one annual shortage of 10 percent in 100 years would be equivalent to an index of 0.01 and one shortage of 20 percent in 100 years would be equivalent to an index of 0.04.

socio-economic factors -- Those elements effecting the system or condition of a community of interdependent individuals and the production, distribution and consumption of wealth as related to the satisfaction of the material needs of those individuals.

source, water supply -- A stream, surface or underground body of water from which a supply of water is or can be obtained.

Standard Metropolitan Statistical Area (SMSA) -- A Standard Metropolitan Statistical Area is defined in the Bureau of the Budget publication, Standard Metropolitan Statistical Areas· 1967, and subsequent publications, U.S. Government Printing Office, Washington, D.C. 20402.

storage -- (1) The impounding of water, either in surface or underground reservoir for future use. The term differs from pondage in that the latter refers to more or less temporary retention of the water, whereas storage contemplates retention for much longer periods, (2) Space in a reservoir utilized to store water.

supply, water -- (1) A general term for the sources of water for public and private uses, (2) The furnishing of a good potable water under satisfactory pressure for domestic, commercial, industrial, and public service, and an adequate quantity of water under reasonable pressure for fire fighting.

supply, water, available -- That amount of water, expressed either in terms of a rate of flow or as a volumetric quantity, which exists in a source of water supply such as a stream, or reservoir, over and above the quantity necessary to supply valid and prior rights and demands. Such demands may be under rights by appropriation, riparian rights, or rights of users or owners of lands overlying a subterranean or ground water basin to the replenishment of their supply from surface sources. The water in question may be either surface or ground water.

supply, water, private -- A water supply from which water is not available to the people at large, its location and outlets being on private property to which the general public does not have access or legal right of entry.

supply, water, public -- A water supply from which water is available to the public at large or to any number of members of the public indiscriminately.

supply, water, regional (as used in the UMA study) -- A regional water supply is a system which has the sources and facilities to serve adequately two or more municipalities, and which results from the integration of any one, or any combination, of the plans, designs, construction, management, or interconnected facilities of smaller systems.

trend -- A statistical term referring to the direction or rate of increase or decrease in magnitude of the individual numbers of a series over a period of time, when minor fluctuations of individual members are disregarded.

Urban Metropolitan Area (UMA) (as used in this portion of the NEWS study) -- An urban metropolitan area is an integrated economic and social unit with a population greater than 50,000 comprising a central city and outlying areas. Its boundaries contain fringe areas whose densities may be expected to approach 1,000 per square mile. For the purposes of this study, a UMA is a water service area which is potentially amenable to regionalized water supply.

yield -- (1) The quantity of water expressed either as a continuous rate of flow (cubic feet per second, etc.) which can be collected for a given use, or uses, from surface or ground water sources on a watershed. The yield may vary with the use proposed, with the plan of development, and also with economic considerations. The term is more or less synonymous with <u>water crop</u>. (2) Total runoff. (3) The stream flow in a given interval of time derived from a unit or watershed. It is usually expressed in cubic feet per second per square mile, determined by dividing the observed stream flow at a given location by the drainage area above that location.

yield, dependable, n-years -- The minimum supply of a given water development that is available on demand, with the understanding that lower yields will occur once in n-years, on the average.

yield, groundwater, potential -- The greatest rate of artificial withdrawal from an aquifer which can be maintained throughout the foreseeable future without regard to cost of recovery. The physical yield limit is, therefore, equal to the present recharge, or that anticipated in the foreseeable future, less the recoverable natural discharge.

yield, safe -- The maximum dependable draft which can be made continuously upon a source of water supply (surface or groundwater) during a period of years during which the probable driest period or period of greatest deficiency in water supply is likely to occur. Dependability is relative and is a function of storage provided and drought probability.

yield, water -- The total outflow from a drainage basin through either surface channels or subsurface aquifers.